# POWER

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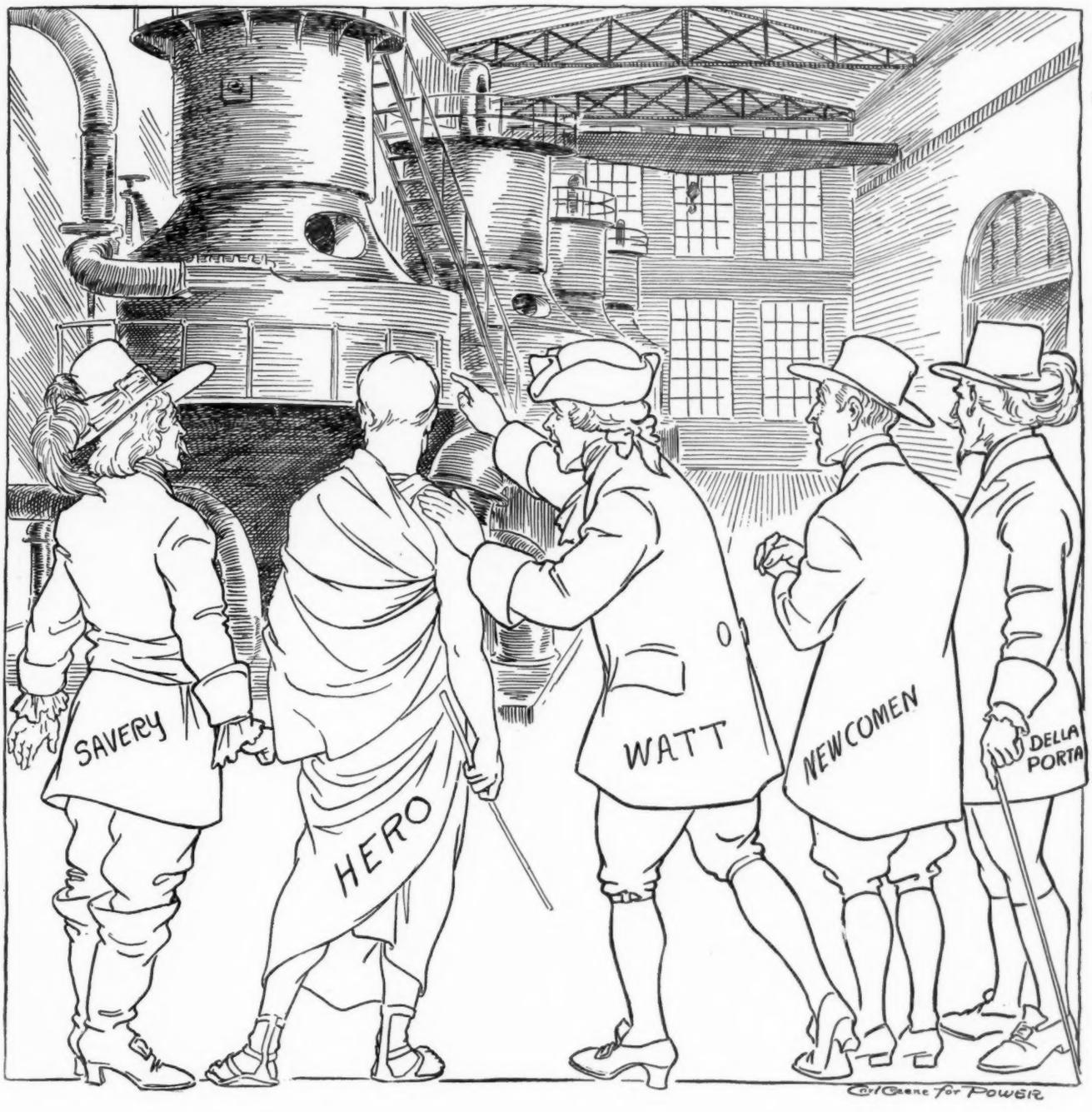



WILL THE FUTURE HOLD AS MANY SURPRISES FOR US?

# Busch-Sulzer Bros. Diesel Engine Plant

By Thomas Wilson

*SYNOPSIS—An interesting oil-engine plant containing exhaust heaters to utilize the heat in the exhaust gases, a special cooler for the jacket water and a hydraulic oil-handling system.*

The possibilities of the oil engine as a factor in the power-plant field in this country have to a certain extent been demonstrated by the works of the Busch-Sulzer Bros. Diesel Engine Co., in St. Louis, Mo. This company has just completed a million-dollar plant for the exclusive manufacture of the Diesel engine. An immediate capacity of from 10 to 15 engines per month is available and provision has been made for extension as the demand increases. J. R. Harris, vice-president and general manager, and Max Rotter, chief engineer, entered prominently into the design of the entire plant, while the Arnold Co., Chicago, were the engineers and constructors for the buildings and the general equipment.

The present group of buildings occupies about one-half of a nine-acre site located a quarter of a mile from the Mississippi River and in communication with excellent railway facilities. There are a service and an office building, the power house, machine shop, forge shop, pattern-storage building and a U-shaped structure, one leg being devoted to the storage of raw material, and the other to finished material and an erecting and testing floor. The machine shop connects the two, so that the process of manufacture is continuous from raw material to the testing floor.

Considerable power is required by the various machines, traveling cranes and elevators. Individual motor drive with push-button control has been employed, and there are about 150 motors in all, ranging from ¼ to 50 hp. They operate on direct current at 220 volts, and are nearly all of the variable-speed type. Tungsten 100-watt lamps are used for yard lighting, 40- to 50-watt lamps are dis-

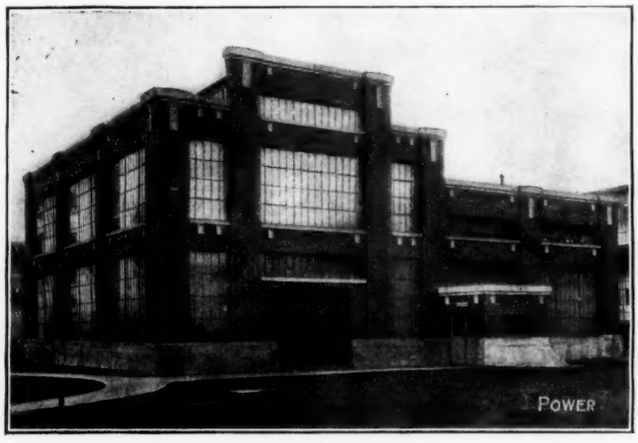



Fig. 1. Exterior of Power House

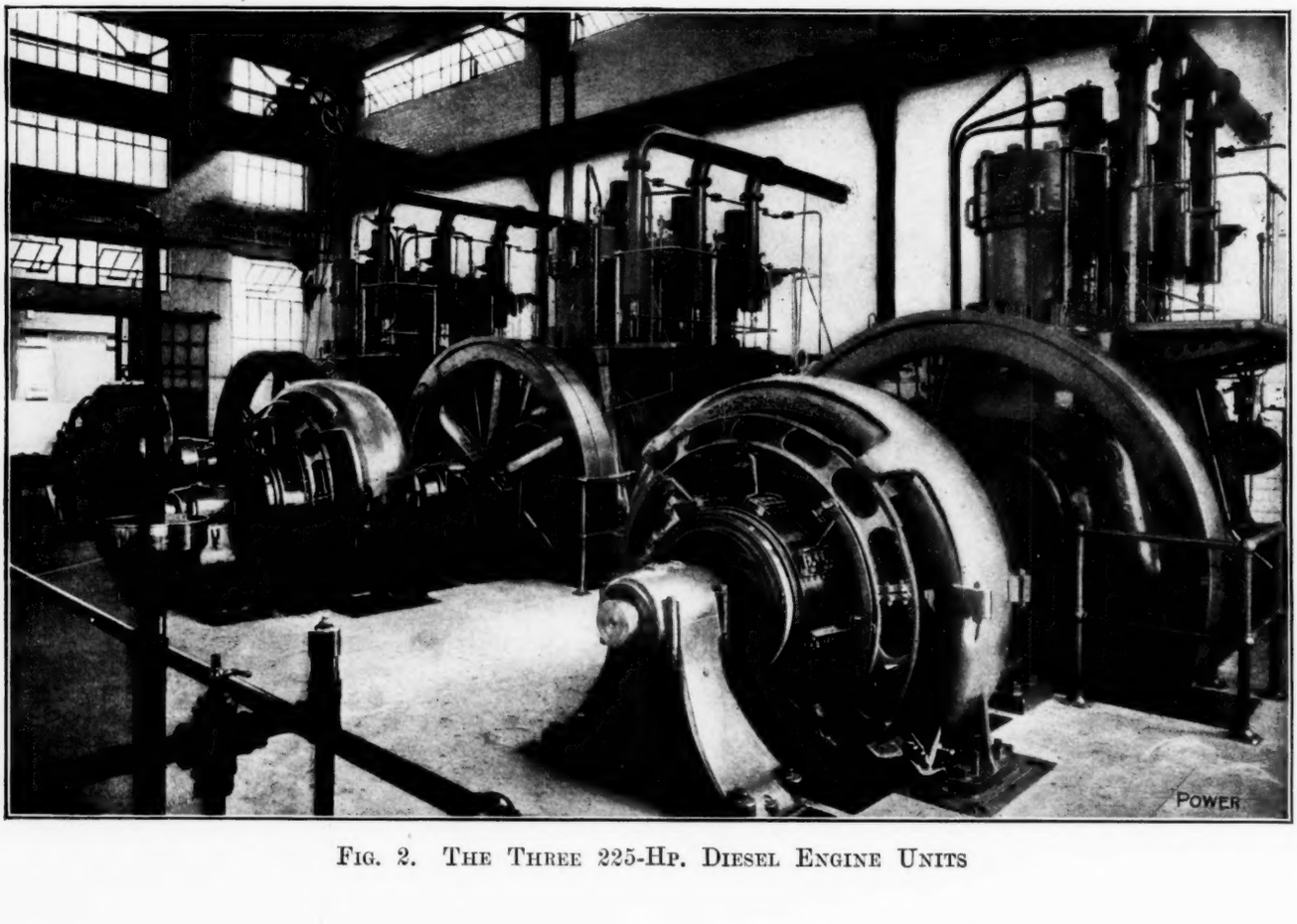



Fig. 2. The Three 225-Hp. Diesel Engine Units

tributed throughout the buildings for special work and for general illumination flaming arcs have been selected. With numerous incandescents in addition to a special watchman's circuit, consisting of 25-watt tungsten lamps, the lighting load should average about 40 kw. Adding to this the average demand of the motors, a total load approximating 400 kw. may be expected.

To supply current for the power and lighting loads, the company has installed an oil-engine plant which is featured by the utilization of the exhaust gases for heating the buildings, a special cooler designed to maintain the engine jacket water below a specified temperature, and a hydraulic oil-handling system. A boiler room may seem out of place in a Diesel-engine plant, but here it was desired to operate a number of hammers in the forge shop with high-pressure steam and to supply some steam to fill in the gap between the heat available from the engines and the requirements during the colder weather, there being 23,000 sq.ft. of radiation. Three 100-hp. Heine boilers to work at 100 lb. pressure have been installed. Oil fuel is supplied through Best burners, one to a boiler, and the products of combustion are carried away through a 3-ft. stack which extends just above the roof. A 90-in. Sturtevant induced-draft fan supplies the air for the three units.

### Engine Room

The prime movers are three 225-hp. Diesel engines, 16x24 in., of the typical vertical three-cylinder type, made by the company. Each is connected to a 160-kw. Crocker-Wheeler, three-wire, 110-220-volt, direct-current generator. Space has been left for a fourth unit of the same size so that the plant will eventually have a capacity of 900 hp. in a room 63x40 ft., which gives 2.8 sq.ft. of floor space per horsepower of rating. At full load these engines will develop a brake horsepower-hour on 0.45 lb. of oil containing 19,000 B.t.u. per lb., or on 8550 B.t.u. As will be apparent in the illustrations, the plant has been laid out on liberal proportions, and care has been taken to secure an attractive appearance. The floors are of concrete with cement finish. A 6-ft. wainscoting of enameled face tile and the piping color scheme (given herewith) add to the general effect. An unusual proportion of glass in the walls and monitor admit the light and fresh air so desirable in an engine room.

COLORS FOR ALL EXPOSED PIPES AND FITTINGS

| | Runs | Valves and Fittings | |
|---|---|---|---|
| Water: | | | |
| City | Blue | Blue | |
| Tower | Blue | Black | |
| Circulating | Blue | White | Except exposed pipes and radiators in first, second, and third floors of office building, which are to be aluminum paint. |
| Heating | Blue | Red | |
| Soda | Blue | Yellow | |
| Air: | | | |
| Suction | White | White | Includes ventilating ducts. |
| Blast—under 5 lb. per sq.in. | White | Blue | |
| Compressed—100 lb. per sq.in. | White | Black | |
| Compressed—1000 lb. per sq.in. | White | Red | |
| Steam: | | | |
| Exhaust | Black | Black | |
| Live | Black | Red | |
| Blow-offs | Black | Green | |
| Exhaust gases | Black | White | |
| Oil: | | | |
| Fuel | Brown | Brown | |
| Gas: | | | |
| City | Yellow | Red | |
| Drainage: | | | |
| Roof drains | Green | Green | Includes all foul water, waste, and overflow pipes connecting to sewers. |
| Soil pipes | Green | Red | |
| Vents | Green | White | |
| Fire service | Red | White | Includes sprinkler systems, steamer connections, and fire hydrants. |
| Electric conduits | Red | Red | |

The following shades of the various colors will be used:—
Red—vermilion; blue—prussian; yellow—chrome; green—emerald; white dead white; brown—burnt sienna; black—dead black.

The air required for starting and fuel injection is compressed by two motor-driven, three-stage air compressors, 10, 6½ and 3 by 12 in., and stored at a pressure of 750 lb. absolute in 14 steel bottles arranged along the wall. Each has a capacity of 1½ cu.ft. and one compressor will supply the demands for the day.

### Cooling Water

Cooling water for the engine jackets is supplied from a 1500-gal. tank on the roof. There is a low-level float control which admits makeup water from the city mains when necessary. A 4-in. main brings the supply to the engine-room floor, from which 2-in. taps lead to each engine. From the jackets the water discharges through 4-in. pipes to a common 6-in. main with an outlet to the hotwell and to a rotary cooler installed by the Power Specialty Co. It then flows to a sump and by means of a float-controlled centrifugal pump is elevated to the tank on the roof. Fig. 5 shows the jacket-water and water connections for the boiler-feed and lavatory pumps.

Fig. 7 is an exterior view of the cooler which is a horizontal cylinder 6 ft. 8 in. in diameter and 7 ft. long. The cooling surface within consists of four rotating drums made up of galvanized-steel plates, No. 26 gage, arranged in concentric rings on a cast-iron center and supported from the shaft by steel spokes; a space of about 3 in. separates the drums arranged lengthwise on the shaft. Between the rings of plates there are narrow spaces, so that when the drum revolves in the water at the bottom of the encasing cylinder, thin films adhere to the surface on both sides of the plate. A large surface is thus exposed to the air blown through the cylinder by a fan mounted at the end and discharged through a flue leading to the roof. A small motor rotates the fan and through chain and friction drives also turns the drums. The cooler has a capacity to abstract 2,200,000 B.t.u. per hr. from 5900 gal. of water at 140 deg., when the dry bulb temperature is 85 deg. and the relative humidity 75 per cent. The hotwell, from which feed is taken for the boilers, is maintained at a fixed level, drawing its supply from the jacket water before it reaches the cooler. By this arrangement a considerable portion of the water is diverted and a part of the waste heat in the jacket water utilized.

### Gas and Steam Heaters

Evans-Almirall hot-water heating under forced circulation has been installed throughout the shops, which are equipped with 23,000 sq.ft. of radiation, mostly in pipe coils. Either of two DeLaval steam turbine-driven 6-in. centrifugal pumps circulate the water, which is sent out through a 6-in. main dividing into a 5-in. line, supplying the southern group of buildings, and a 4-in. to the northern group. At a temperature of —5 deg. F., of which St. Louis averages about three days annually, the heat loss from the buildings figures 7,250,000 B.t.u. per hr. With the usual drop of 30 deg., 241,670 lb. of water per hour, or about 480 gal. per min., would be required to supply this amount of heat, which would be given up at the rate of 315 B.t.u. per hr. per sq.ft. of surface. The requirements as computed for temperatures ranging from —5 to 55 deg. and the number of days of each temperature are given in Fig. 8. At a temperature of 35 deg., an approximate average for the winter, the heat loss drops

to 2,790,000 B.t.u. per hr., a little over one-third of the maximum.

To supply this heat the plant has been equipped with three "Riblett" cast-iron gas heaters, one for each engine, made by the Williams Tool Co., Erie, Penn. An exhaust-steam and a live-steam heater are also provided, so that the maximum temperature of the water may be attained in three steps. In mild weather the gas heaters will supply sufficient heat, at the average winter temperature the exhaust-steam heater will be needed and in the coldest weather the live-steam heater must be used. The heaters are so piped that any one of the three, or any combination, may be put into service. The water circuits of the gas heaters are arranged in multiple, and one, two or three heaters may act as one unit. The live-steam heater receives its steam direct from the boilers at 100 lb. pressure, while the exhaust from the turbine-driven pumps of the heating system, the boiler-feed and lavatory pumps, and the induced-draft fan engine goes to the exhaust-steam heater. The condensation from the heaters is discharged by a duplex pump into the boiler-feed line through a check valve, with a relief valve opening into the hotwell.

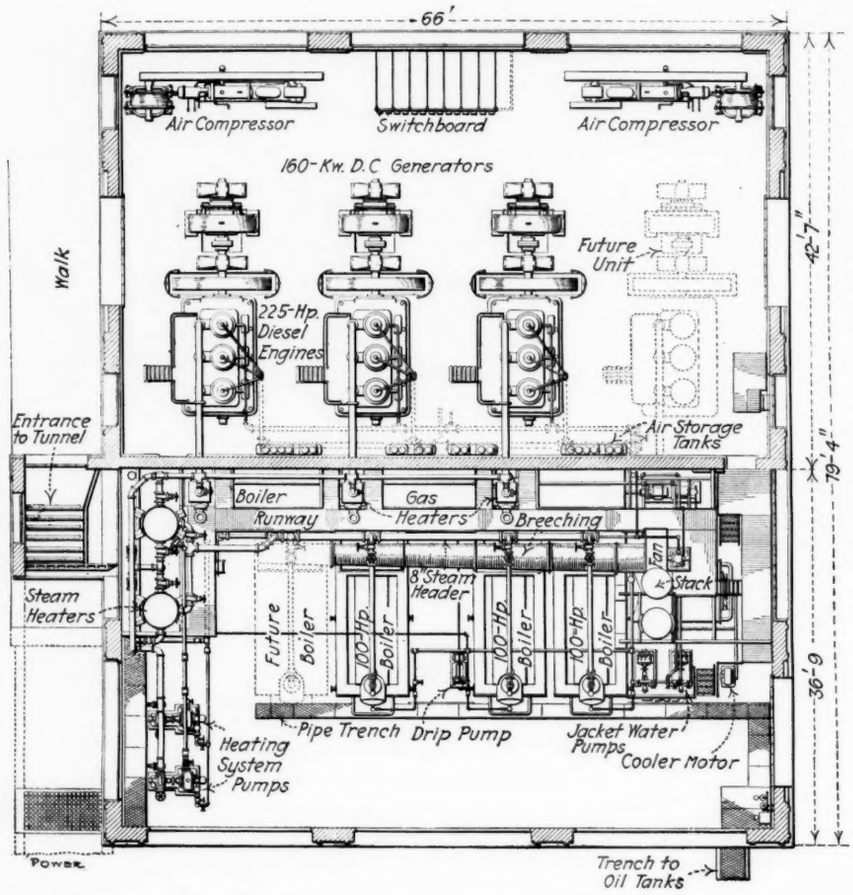



FIG. 3. PLAN OF POWER HOUSE

Each gas heater has 200 sq.ft. of surface, and is guaranteed to raise the temperature of 5700 lb. of water from 140 to 170 deg. (equivalent to 171,000 B.t.u.) when the engine is operating at full load and delivering in the exhaust gases 290,000 B.t.u. per hr. to the heater, the temperature of the gases to be 500 deg. With the engine using 0.45 lb. of oil per kilowatt hour at 19,000 B.t.u. per

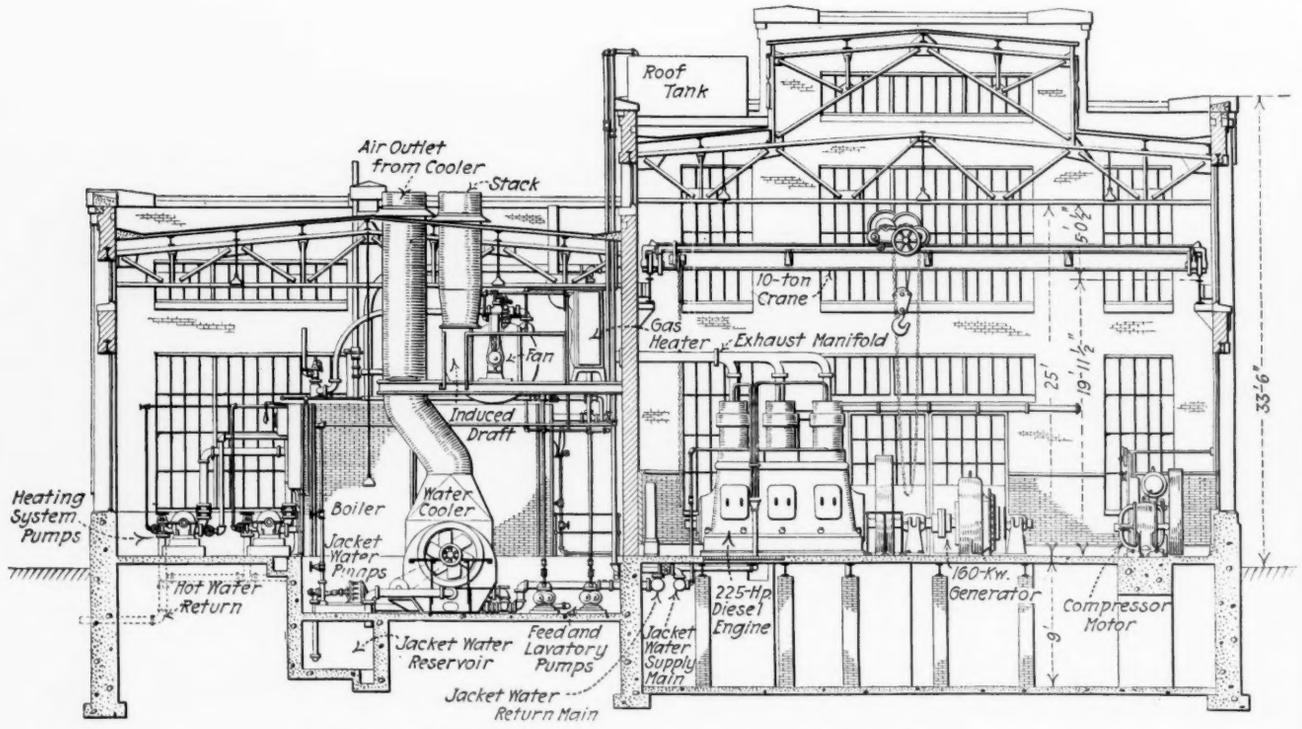



FIG. 4. SECTIONAL ELEVATION THROUGH POWER HOUSE

lb., the 290,000 B.t.u. is about 15 per cent. of the heat in the oil, and of this the water passing through the heater abstracts about 171,000 B.t.u., or 60 per cent., which is equivalent to about 9 per cent. of the heat delivered to the engine. The three heaters would then give to the water 513,000 B.t.u. per hr. The gas is conveyed through an 8-in. pipe to each heater and is discharged through a flue leading to the roof.

Reference to the foregoing paragraph and to Fig. 8 will show that the gas heaters will supply sufficient heat for the shops in weather averaging 55 deg., of which there are 40 days during the heating season. At the average winter temperature of 35 deg., they will supply about 20 per cent. of the demand, and the exhaust heater will just

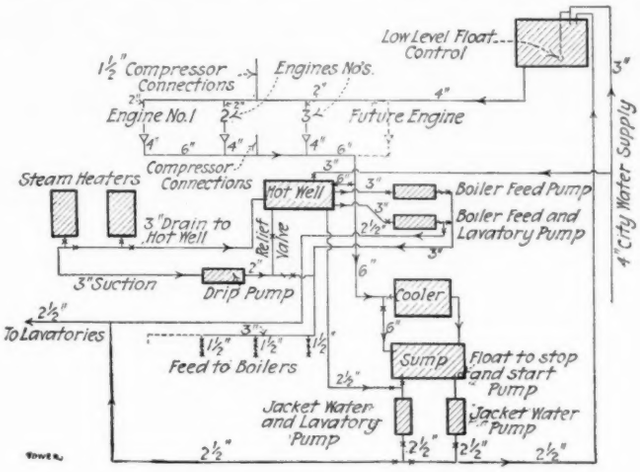



FIG. 5. LAYOUT OF WATER PIPING

about care for the other 80 per cent. Below 35 deg. it will be necessary to cut in the live-steam heater, using just enough steam to raise the water to the temperature required.

### OIL SUPPLY

The plant has storage capacity for 60,000 gal. of oil made up of five 12,000-gal. tanks 8½ ft. in diameter and 32 ft. long. The tanks are encased in concrete and have their tops 2½ ft. below grade level. Three of the tanks are about 300 ft. south of the power house near the testing pit and the other two are back of the boiler room.

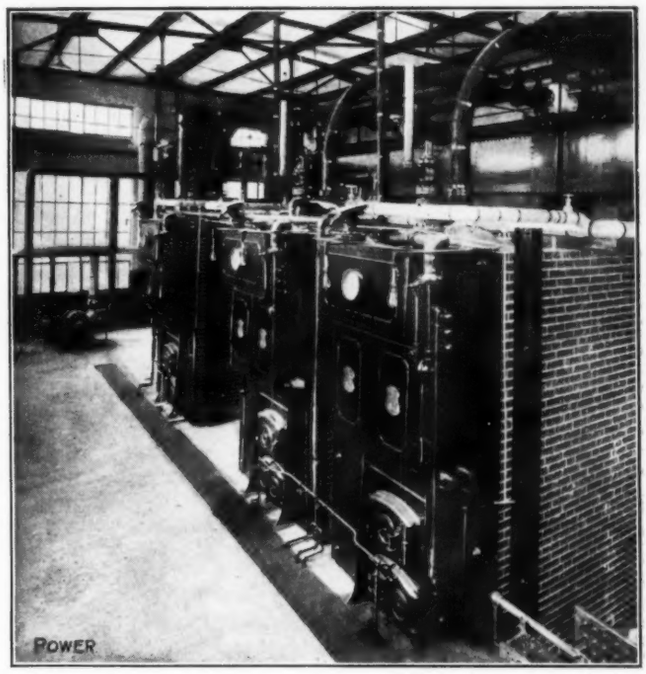



FIG. 6. BOILER ROOM

The oil is delivered in car shipments to the three tanks near the testing pit, where oportunity is afforded for testing before it is transferred by a small rotary pump to the tanks near the boiler room. Oil for the engines and boilers may be drawn from either tank or the same tank. It is supplied through separate lines with a meter on each to measure the consumption. The oil reaches the burners of the boilers under a head of about 4 ft. and in the engine room is delivered to an auxiliary tank 8 ft. above the floor level, from which it flows to the oil pumps on the engines.

A hydraulic system has been installed to handle the oil in the plant. In operation, this system depends upon the difference in specific gravity between the oil and the water. A column of water connected to the bottom of the oil-storage tank forces the oil to the point of demand, the pressure at the delivery end depending upon the height to which the column is carried. The principal elements of the system are a control valve to turn on the pressure

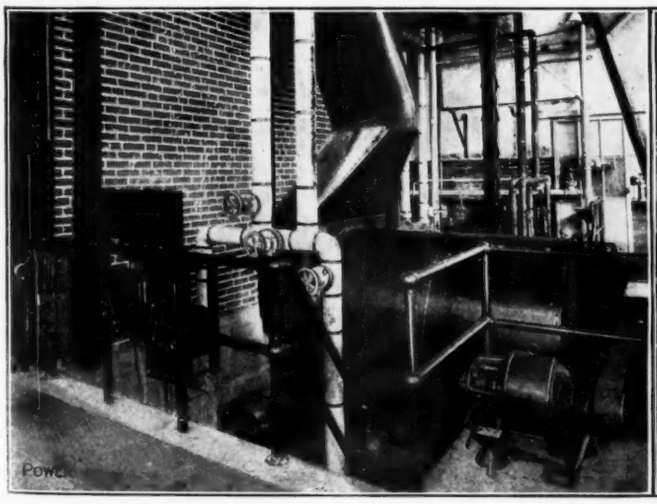



FIG. 7. JACKET-WATER COOLER

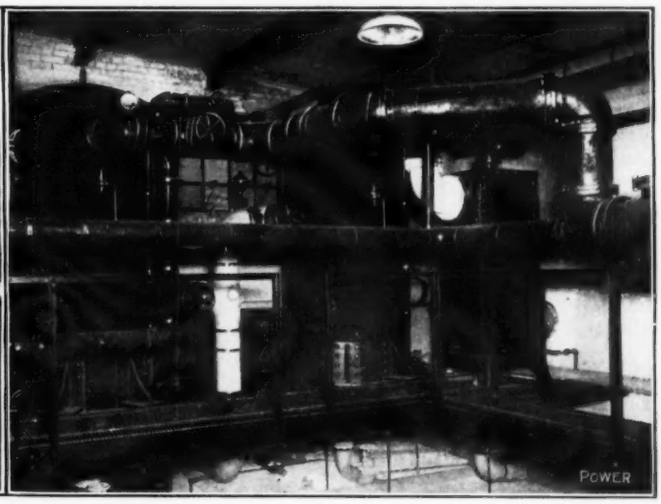



FIG. 9. GAS AND STEAM HEATERS

and a float box connecting with the city mains to insure a constant head.

To prepare the system for operation the lever of the water-control valve is raised. This closes the port leading to the water-discharge valve and opens the port leading to the water-float box, so that the water can flow down through the leg at the bottom of the storage tank and up into the tank itself, where a deflector spreads it evenly. The water rising in the tank forces out the air ahead, and its appearance in a gage-glass indicates that the tank is full and that all the air has been expelled. The lever is

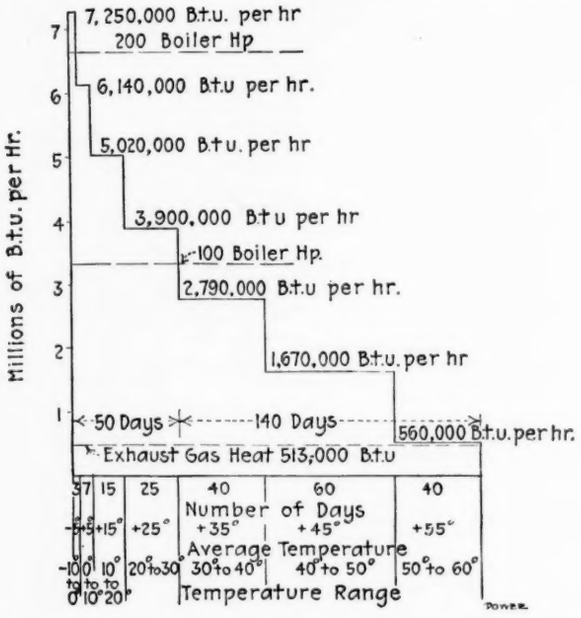

7,250,000 B.t.u. per hr
200 Boiler Hp
6,140,000 B.t.u per hr.
5,020,000 B.t.u. per hr
3,900,000 B.t.u per hr
100 Boiler Hp.
2,790,000 B.t.u per hr.
1,670,000 B.t.u. per hr
50 Days
140 Days
560,000 B.t.u. per hr.
Exhaust Gas Heat 513,000 B.t.u
Millions of B.t.u. per Hr.
37 15 25 40 60 40
Number of Days
+15° +25° +35° +45° +55°
Average Temperature
10° 20° to 30° 30° to 40° 40° to 50° 50° to 60°
0° to 10° to 20°
Temperature Range
POWER

FIG. 8. ESTIMATED HEAT LOSSES FROM BUILDINGS

then dropped, closing the port to the water-float box and opening the port communicating with the water-discharge pipe. This allows the water in the pipe above the water-controlling valve to return to the storage tank and discharge an equal volume of water to the sewer.

Having been freed from air, the system is then ready to receive oil. This is introduced into the top of the tank and a deflector spreads it evenly over the surface of the water. The oil forces the water out of the tank through the water pipe and water-controlling valve to the sewer until the column of water from the control valve down, balances the oil column and prevents further admission.

To start the flow of oil toward the points of consumption, the lever of the water-controlling valve is again raised, closing the discharge port and opening the port to the float box. Water then passes into the tank under the oil and forces it out of the top of the tank to delivery points. Up to the control valve the column of water balances the oil column, so that the head from the control valve up to the water level in the float box is the factor controlling the pressure at delivery. In the present plant this head is about 42 ft., representing a pressure of 5 lb.

**To Electrify Selkirk Tunnel**—Westinghouse, Church, Kerr & Co., Montreal and New York, have been retained by the Canadian Pacific Ry. as engineers to investigate the matter of the proposed electrification of the new double-track, 5½-mile Selkirk Tunnel in British Columbia. The investigations will cover in general the type of system to be installed, the relative economies of steam and water power and the effect of the electrification upon operating conditions.

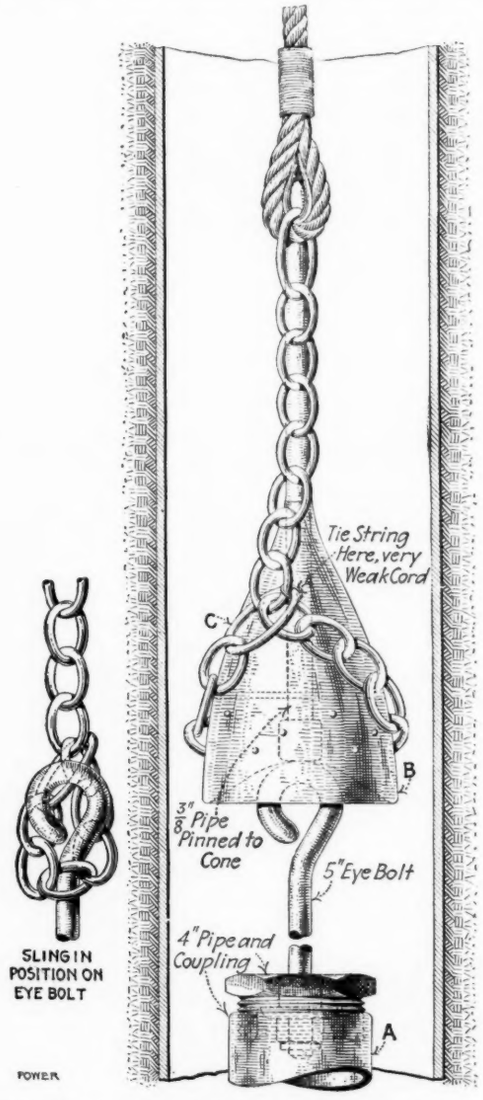
## Fishing for Pipe in Deep Well

BY EDWARD O. JOHNSON

The writer was called upon to fish a 4-in. pipe about 70 ft. long from a well in which it had fallen, owing to poor tackle used for lowering the pipe into the well.

The top end of the pipe was fitted with a coupling and a bushing *A* screwed in tightly as shown. Through the hole in the bushing was a ⅝-in. eye-bolt swiveled to allow screwing the pipe on the piece below. Just how much of the tackle remained in the well was unknown, for the drop was so sudden that nobody seemed to remember just how the tackle looked.

However, since we could not find it outside the well,




SHOWING HOW SLING WAS SLIPPED OVER EYE-BOLT OF WELL CASING

we concluded it was in the well. We fished for a few hours and finally hooked on something that felt like an eye-bolt. Finding it was fast we prepared for the final task of getting the 70-ft. length of pipe up the long lift. From the surface of the ground to the water was approximately 30 ft.; the top of the pipe was down 20 ft. further. We coupled three lengths of ⅜-in. pipe and made a cone *B* of wood small enough to go in the 8-in. casing and leave an annular space around it of about

two inches. The under side of the cone was hollowed out and the outer surface sheathed with strips of tin.

A short piece of chain with a ring *C* was used as a sling and secured to a rope for hoisting. The sling was tied open by a weak piece of cord, which was designed to break when the rope holding the chain was jerked. First the wooden cone and pipe were let down carefully until we were sure the cone was directly over the eye-bolt and resting on it. We then let down the sling tied open and very carefully (lest we should break the tie string) felt it stop at the cone. Gently we forced the sling in over the cone until it was again going freely down the well. When it had passed the top of the pipe a foot or more a sudden jerk was given to the sling in the hope of breaking the tie string, thus allowing the ring to slip over the chain and close the sling.

The third attempt to grab the eye-bolt was successful, and the way that sling adjusted itself and held could not have been better had it been put on by hand. This method is practical in emergencies.

# Packing for Hydraulic-Elevator Valves

By R. A. Cultra

*SYNOPSIS—A description of a method of renewing cup leathers on pilot and main hydraulic-elevator valves. Also the manner of making the leather packing cups at the plant.*

Most pilot and main valves of hydraulic elevators are packed with pressed-leather cups or rings of suitable shape. These valves resemble the piston valve of a steam engine. They have two disks on each end of a short spindle. A cup is fitted over each inner disk, and is held

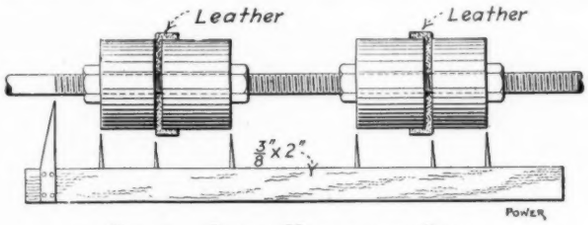



Fig. 1. Pilot Valve and Gage

tight by the outer disk, as shown in Fig. 1. Some of these valve spindles require skill in putting on the leather packings, especially where the disks are screwed on the stems, and held tight by nuts, lest the position of the disks on the stem or the distance between them be changed.

Lengthening or shortening of this distance will cause the valve to leak or fail to open to the full port opening, which will cause the main valve to be slow in responding. If the pilot valve leaks, the car is apt to start and endanger the passengers and operator.

It is good policy before removing the old leathers from the disks to take a piece of 3/8x2-in. board, the length of the valve, and mark on the edge the exact position of the disks. Then drive small nails or pins in the edge of the board and file off sharp. This makes a gage, which can be preserved for future use, and the disks can be replaced in their exact position with the leather cups between them on each end and screwed up tight, as illustrated in Fig. 1.

Both pilot and main valves may be constructed in the manner as described. There are also both pilot and main valves having the two inside disks cast in one piece with a hole through the center through which the rod passes; both disks are machined so that the distance between them is such that the disks will cover both ports in the valve case. This type of valve is less liable to be misadjusted when renewing the leather packings, as it is only necessary to remove the locknut and one follower disk on one end of the spindle and the two center disks can be slipped off the spindle without disturbing the locknut and follower disk on the other end.

The leather cups for packing can then be put on the stem and the disks replaced in their original position with little risk of getting them out of adjustment, even if the gage is not used.

There is a slight variation in the space allowed between the valve piston and the casing for the leather cups to fill and care must be taken to have the leather of the right thickness. If they are made of too thin leather, although they may be a nice fit, they will wear away quickly; if too thick it will be hard work to replace the

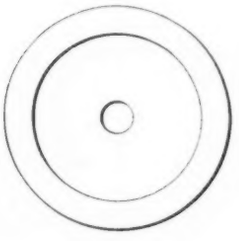


FIG. 2
BOTTOM-HALF OF DIE

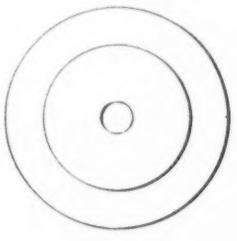


FIG. 3
TOP-HALF OF DIE, BOTTOM UP

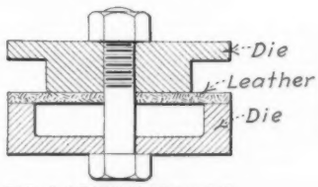



FIG. 4 LEATHER SET IN DIE READY TO BE PRESSED

FIG. 5
LEATHER CUP

FIG. 6
SIDE VIEW OF LEATHER CUP

POWER

piston in the valve case and there will be danger of cutting the leather cups on one side.

This difference in the thickness of the leather from which the cups are made is generally the cause of misadjustment in reassembling the piston. Leather disks can be obtained from the manufacturer, but these are not always satisfactory, as they are usually hard and dry, vary in thickness and if allowed to stand in stock for some time, will frequently crack, and become unfit for

use. But if they are of the proper thickness and in good condition they can be soaked in luke-warm water and put in place. They will generally wear well because the fiber of the leather has been compressed in the making, but are hard to enter into the case on this account.

Some engineers prefer to make the cups and rings, as the stock can be picked and they are not pressed quite so hard, are flexible when used and, as the leather is selected of the right thickness for the cups and rings, there is little trouble in entering the pistons into the casings.

To make these cups a special die for each size and some form of press to shape them is required. Fig. 2 is the bottom half of such a die; Fig. 3 is the top half.

The leather is cut into disks enough larger than the cylinder to give depth to the cup. A bolt is passed through the center of the die. The leather is soaked in luke-warm water and placed between the dies as shown in Fig. 4. The bolt is then tightened, drawing the two halves of the die together, which presses the leather into the shape of a cup. It is allowed to stand long enough for the leather to partially dry and assume its shape.

Fig. 5 shows the leather after being pressed into cup shape. Fig. 6 represents the shape of the leather, looking at it edgewise.

It is not always convenient to press the leather with the bolt as illustrated in Fig. 4, but it can be done if no better means are at hand. A bench vise can be used to good advantage for pressing the die together and much time and labor saved by its use.

# Modern Boiler-Room Practice*

By Charles H. Bromley

*SYNOPSIS—Deals with heat losses due to excess air. Sources of excess air. Finding the correct draft and depth of fuel bed for given loads. Limits of the duties of firemen. Poor and good practice in flue-gas sampling. Soot troubles. Large furnace volume allows of more complete combustion of high volatile and therefore cheap coal; high combustion rates may be had with the fine grades of anthracite without it being carried over the bridge-wall. Most manufacturing plants needlessly suffer heat losses due to running boilers below rating. Furnace heights and ratio of boiler to kilowatt capacity as practiced in large plants. Hints on purchase of coal.*

This subject is so broad that I can hit only the high spots in a single evening's talk.

Consider a boiler as something of two distinct parts, a furnace where combustion of the fuel takes place to produce heat, and a shell containing water to absorb that heat and furnish steam. Successful boiler operation lies in getting as much of the heat in the fuel into the water in the shell as is practically possible. Consider the two parts of a boiler as distinct, because you may have the best possible furnace efficiency while the heat-absorbing efficiency of the heating surface may be extremely low, due to scale and soot accumulation.

## Excess Air

If, in filling a 10-quart pail from a faucet, part of the stream ran on the outside of the pail, more than 10 quarts of water would have run from the faucet when the pail was filled. That which did not go into the pail would be excess water. Theoretically, 11.6 lb. of air is required to burn 1 lb. of coal. Practically, 20 to 24 lb. is needed. The difference between 11.6 lb. and 24 is the excess amount—excess air. As boiler-room practice goes, the excess air admitted to the furnace may be, and generally is, 50 to 400 per cent. From 25 to 45 per cent. excess air must be admitted to the furnace to obtain complete combustion and the heat it is possible to produce.

The greatest of the heat losses result from the following causes: Too much air admitted, even though it is well mixed with the gases, as when the draft is too strong for the thickness of the fire or the fire has "holes," or when there is much leakage of air through the setting at the first and second passes. The draft may be correct for normal conditions, but owing to the presence of a proper combination of iron, silica, lime, sulphur and clay in the fuel, the coal may clinker and slag, stopping the admission of the right amount of air through the grate. Then CO instead of $CO_2$ will form and about only one-third of the heat will be obtained from the same amount of fuel as would be obtained if it were burned to $CO_2$.

As for draft, we are interested chiefly in the volume of gases passing over the heating surface, because on this depends, almost solely, the rate of steam production, provided we have apportioned the air supply correctly and the boiler is clean. Therefore, for a given fuel and grate we can determine the thickness of fire and the boiler draft (pressure difference between the furnace and uptake) that will give the best results for a given load. This condition of fuel bed and draft must be determined for each load condition on each boiler.

Coals of different constituents require different amounts of air. Every shipment of fuel varies in quality and constituents. To save being on his feet too much the fireman covers the fire too heavily. Many firemen turn the fire upside down and mix much ash with the white-hot coal every time they use the slice bar. The ash melts and by the time it reaches the grate it has cooled and formed slag and clinker, increasing the resistance of the fuel bed. This fire is not attended to because the clock does not say it is time to do so. This boiler loafs and wastes fuel. The other boilers are worked harder to carry the load and this condition prevails until cleaning time by the clock, not by the state of the fire. Here is where a steam-flow meter serves well as a check on the work of the boiler.

Every fireman should understand that just as much fuel can be wasted by excess air coming in through uneven and too thin fires as through an open furnace door. Too much air is too much, no matter where it comes in.

## Limits to Duties of Fireman

Too much is expected of the fireman. His duty is well done and ends when he maintains the correct height of, and a level, even burning fire, regulates the draft to

*From a lecture before Newark, N. J., N. A. S. E., No. 3.

suit the load and fuel conditions, maintains a uniform water level, and keeps soot out of the boiler. Finding air leaks in the setting with a torch or candle and stopping them with cement or waste and fireclay, determining the proper height of the fire and correct draft for the load conditions, is the engineer's job. You cannot fire boilers with a template. The fireman must use some judgment, but the fuel and load conditions in nearly every plant admit of finding what furnace adjustments are needed. Find what these adjustments are by closing all air leaks in the setting and its doors and the boiler headers, and analyzing for $CO_2$ until the thickness of fire and draft is found that will produce the highest $CO_2$ and still make the boiler do its share of steam making.

Hold the fireman to these adjustments. You must rely on him to care for the slight exceptions to the routine you have laid out for him, and you should check his day's work by $CO_2$ analysis or charts and by recording the coal and water used.

In the 201st St. station of the United Electric Light & Power Co., New York City, the boiler settings are incased in steel with insulation between the brickwork and the steel. These casings cost a lot of money, but the saving in heat losses by radiation and infiltration of air is expected to pay for them and earn money on the investment, as interest is paid on bank deposits.

If the settings are scraped and painted, first use a thin mixture of fireclay or cement, or preferably both, and let the bricks soak in all they can. If an asphaltum-base paint is used, be sure to get one that will not run at the temperatures dealt with. Asbestos board covered with canvas and painted makes a good final covering if cared for properly.

### $CO_2$ Recorders

Any $CO_2$ recorder is a delicate instrument, and to prove successful must have one or two responsible individuals to care for it. In too many plants this person is a boiler-room helper, an oiler or the fireman, or all jointly take a hand in "getting it going." The engineer is the one properly responsible. He should instruct one or two firemen or an oiler how to care for it, but should not leave the machine solely in their hands until he is sure that they are competent.

I think it poor practice to have one single recorder piped to a number of boilers unless the valves which put the machine in connection with any boiler are housed and locked. Even then the fireman can discover easily to which boiler the machine is connected by manipulating the furnaces, one at a time, meanwhile watching the recorder for marked variations in the reading. This connected boiler will then be made to loaf on the line, the damper and fire being regulated to produce high $CO_2$. The gain due to driving the other boilers harder is offset usually by the losses occasioned by the loafing boiler.

The valves controlling the water inlets and outlets of gas-sample collectors should be locked to prevent false samples being collected. If unlocked, a fireman can fire badly nearly all day and at the end of his shift produce high $CO_2$, fill the collector with water, get an instantaneous sample while the $CO_2$ is high and be credited with an excellent day's work.

It will be found expedient to provide a shelf for the gas analyzer at the collector and draw gas from the collector direct instead of using cumbersome bottles to contain the gas.

### Soot

Soot works a threefold harm. It lowers the heat-absorbing efficiency of the heating surface; it obstructs the gas passages through the tubes which necessitates more draft for a given steaming rate; it contains more or less sulphur, and if the soot gets wet from leaks, sulphurous and sulphuric acids are formed, causing corrosion of the tubes. The day will come when permanent soot blowers will be installed with every boiler just as stop valves are installed.

Stoppage of gage-glasses and blow-off pipes must be guarded against as the former trouble has caused some disastrous explosions.

### Furnace Volume

It seems strange that after all which has been said of the value of high settings, or large furnace volume, there should be so few in new boiler installations. The only loss is that by radiation and air infiltration, which is negligible, as both may be reduced to a minimum. Combustion will be complete before the heating surface is reached, and high furnace temperature, which is most essential to economy, may be maintained. The volatile combustible, containing so much heat, will give that heat instead of forming smoke and soot. Highly volatile and cheaper coal may be used to advantage. Slow gas velocity in the furnace with comparatively high combustion rates is possible, and fine coal may be burned without a large percentage of it being carried over the bridge-wall or to the tubes and the stack. It is a fact that "soot" taken from back of the bridge-wall has had a heat value of as much as 12,000 B.t.u. per pound. The cost of high settings, and possibly of higher buildings required for them, is many times offset by the reduction of heat losses over low settings.

At the South Boston station of the Boston Elevated Rys. Co., the B. & W. boilers are 8 ft. above the stoker grate at the rear. At the 201st St. station of the United Electric Light & Power Co., New York City, they are 10 ft. above; at the Northwestern station of the Chicago Commonwealth Edison Co. the front header is 13 ft. 3 in. from the floor; at the Delray station of the Detroit Edison Co. the gases travel 28 ft. from the underfeed stokers before they strike the heating surface; an 84-in. by 18-ft. horizontal tubular boiler at the plant of the North Newark Cold Storage Co., Newark, N. J., is 72 in. above the grate. High settings are as advantageous in small as in large plants.

The ideal condition, and one that can be closely approached, is to have the setting high enough so that no visible flame will be noticed touching the heating surface, even under reasonably high ratings. The flame should consume itself before leaving the combustion chamber. At very high ratings and with long flaming coal, the flame reaches great heights. Here is an extreme example: With 275 per cent. rating and long-flaming West Virginia coal, the flame reaches the top of the combustion chamber in the Delray boilers at the Detroit Edison Co. This shows how much too low are 24-in. settings.

### Combustion Rates

Next to heat losses by excess air because of leaky settings and improper firing, are those due to combustion rates far below the capacity of the boiler. Comparatively few plants are not subject to this usually inexcusable

practice. Rated boiler capacity is partially disregarded in good operating practice, but while it is good as a guide in designing and buying, there is not much use for it in operating when care is used in forcing the boiler.

The boiler room represents a large part of the total power-plant investment. When boilers are run far below rating, the loss is double. Interest, insurance, depreciation, all large items in boiler practice, must be charged against all boilers in excess of those actually needed for the steam requirements, and also those needed for reserve or emergencies. In addition, the investment for those boilers not really required may be considered a nearly complete loss unless a corresponding increase in steam capacity will be needed soon after the initial installation. The other loss is a heat loss. As boilers are run below capacity, the excess air admitted increases rapidly, the $CO_2$ percentages drop likewise, and the fuel losses due to low $CO_2$ are too well known to be discussed.

Maximum boiler efficiency is nearly always obtained at a rating much below normal. The drop in efficiency is quite small for ratings as high as 200 to 300 per cent. Where peak loads must be handled, it might, and often would be, more economical to operate the boilers at 200 to 300 per cent. rating for a short time to carry the peaks, than to carry banked fires under standby boilers. This practice admits of greatly reducing the heavy overhead charges in the boiler room, which are such large factors in increasing the unit cost of power. The amount of overload must always be governed by the quality of the feedwater and the cleanliness of the heating surface.

The day is not distant when a far greater ratio of boiler capacity to that of the prime movers will prevail in manufacturing plants, especially those subjected to peak loads. This practice is being vigorously followed out in large central stations and railway power houses. As much as 4.7 kw. is being allowed per rated boiler horsepower.

Owing to future growth or other local conditions, overhead charges on the boilers installed to care for the future demands are unavoidable. The overall expense is needlessly increased when all the boilers are run considerably below rated capacities, as is common practice. Wherever possible, building and equipment foundations should be put in, and as the demand compels, the building and equipment are extended accordingly. This is done in the best central-station practice, and there is no real reason why it will not apply in most rapidly growing manufacturing plants.

### Troubles Due to High Ratings

Deterioration of furnace walls and stokers is considerably greater at high than at low ratings. In some plants the question of how much firebrick per unit of delivered steam one can afford to burn, determines the boiler ratings.

### Firebrick Troubles

The brick walls in modern boilers do not support more than their own weight, and this makes possible much higher combustion rates than if these walls were loaded. The melting and fusing temperatures of firebrick, or the temperatures at which it becomes soft under its own load, are of great importance. Inseparable from this is the quality of mason work in the walls, and the lineal expansion of the brick under furnace temperatures. Brick that expands too much will surely cause the walls to bulge. The inspection of the setting must be as thorough as that of the heating and steam surfaces when high rating obtains.

The fusing temperature of the brick may be influenced by the slagging quality of the ash. The firebrick may fuse at, say, 3000 deg. F., the ash slag at 2600 deg., but in combination in a furnace both may slag at, say, 2400 deg. When the furnace temperature is below the fusing temperature of the brick and the brick and the ash fuse considerably, it will pay to get a coal having a different proportion of constituents to prevent excessive slagging of the firebrick.

### Tube Troubles

Many operating engineers fear that at very high combustion rates, the steam bubbles are formed so rapidly that they do not allow the water to make good contact with the tubes, and consequently there is grave danger of overheating. Experience shows that with clean tubes and good circulation, the water will absorb the heat as rapidly as it is practicable to supply it. The danger lies in scaled or scaled and muddy tubes. At high rating, therefore, great care must be taken to precipitate the suspended matter and neutralize the scale-forming solids, especially those that form sulphate scale. The nature of the feed water may make it hazardous without being thoroughly treated to run at extremely high ratings. The Passaic and the Delaware Rivers (New Jersey) are examples of such waters. Before boilers heretofore run at or below normal rate are to be run at very high rates, it should be positively known that the tubes are clean to the metal. It is not uncommon to find boilers having scaled tubes which were thought to be free of scale.

If soda-ash is used and there is to be a change from low to high ratings, the amount of soda-ash should be reduced until it is known what quantities may be supplied without causing severe foaming and priming.

### Corrosion

The most widely accepted theory of corrosion is the electrolytic. Briefly, it is this: The substances composing the metal are not intimately and thoroughly mixed and distributed. Electrically, some substances are negative and others are positive. The water or dampness covering the metal acts as an electrolyte to set up a flow of current between one positive substance and one negative. The metal goes into solution at the point from which the current flows and pitting begins. Experience shows that pitting is often started at places on the plate where pieces of scale or other foreign substances have been deposited.

Boilers left full of water while out of service often suffer from external corrosion, because the cool heating surface condenses the vapor in the air, the vapor covering the surface, which soon corrodes. Corrosion from wet soot has been mentioned.

Where creek and river waters are used, and especially if the streams drain coal, iron or other mining districts, the corrosion will usually be severe. During the spring, when the snow melts, much acid is carried by the waters that drain mining districts and often the water must receive special treatment. "Home" remedies are not to

be recommended for such conditions. Be sure to closely inspect for corrosion where tubes enter the heads or headers. I have seen tubes eaten away to $\frac{1}{32}$ in. thick at these points. After cleaning the tubes, examine them by the aid of a portable electric lamp pulled through from one or both ends. Never allow men to work in a boiler which is being filled with steam through a leaky stop valve without having one man to watch and play a hose into the boiler. It is difficult to pull an unconscious man through a manhole.

### Other Considerations

If a plant designed for saturated steam is to use superheated steam, stop valves and gaskets should be adapted to the new conditions at the time the superheaters are installed. Failure to do this has turned 75 per cent. of the operating engineers against superheated steam.

Where coal costs more than $3 per ton and the plant's capacity is reasonably high, the value of economizers is unquestioned. Small plants will not find them advantageous unless the exit gases are of a very high temperature or the water is used for industrial purposes.

Automatic stop valves should be considered as necessary as safety valves. In preventing a shutdown of all boilers in case of accident to one, these valves would save far more than their cost.

### The Purchase of Coal

The cost of coal in any kind of plant will be between 55 and 75 per cent. of the total power cost. An average in well conducted plants, favorably located, will be 65 per cent. The chief reason for scientific methods of purchasing are, therefore, sound, even though the power cost in manufactories is only 2 to 7 per cent. of the total cost.

An example worthy of mention to show the effect of the increasing price of fine grades (Nos. 2 and 3 buckwheat) of hard coal, and as evidence of the necessity of careful buying, is that presented by practice in a large Eastern textile manufactory. About 18 years ago this firm saved approximately $50,000 a year on about 45,000 tons by using these instead of the large grades. Today, with the most careful buying and burning, $600 a year is the best saving possible on the same consumption. The first year New York City bought coal under specification, a total saving of over $200,000 was realized. New York State will hereafter purchase coal under specification, and by prudent buying and slight corrections in the boiler-room practice of its 42 institutions, expects to save at least $250,000 a year.

No explanation is necessary to convince one of the value of buying coal on specification, but much needs to be said of the character of the specifications.

The purchase of coal on a strict British thermal unit basis is wrong to the dealer and the user. The heat value in British thermal units may be high, but the fuel may be so unsuited to the furnace and grate that it would be prohibitive. Further, the probability that the samples on a large shipment reduced finally before analysis to about a thimbleful, are not truly representative, is too great to be a deciding factor. The power plant is not a laboratory, and practical methods are necessary in all its departments.

If the coal is bought strictly on analysis, the percentage of ash, volatile combustible, sulphur and the limits in heat units should be specified for each kind and grade of coal. Whether or not the allowable moisture content should be specified is a question on which authorities are somewhat divided. I understand that the Bureau of Mines recommends disregarding it, partly; it is not mentioned in the New York State specifications, the reason being that neither the miner nor the dealer can well control it, and as the coal is weighed at the point of delivery and the payment is based on that weight, the purchaser may gain by the drying of the coal in transit, or the dealer may gain by rains or leakage in boats while the coal is in transit. Personally, I believe a limit for moisture should be set when the weight of the coal "as delivered" is paid for. Large shipments of fine coal can hold a large amount of water. Also there is too much temptation to "saturate" it before weighing. Comparatively useless water should not be bought on a coal-price basis.

Whether a bonus should be paid on coal of a quality better than specified, is a much discussed question. The experiences of many large consumers who buy on an evaporative basis show that on thousands of tons delivered but little coal is of better quality than specified. It runs below usually, but not so much as to warrant penalizing the dealer, except at rare intervals. A new dealer, unfamiliar with the methods of the consumer, will frequently try to "get by" with a shipment inferior to the trial sample, but when he learns that the quality is being checked with that specified, and that he must either suffer a reduction in price commensurate with the inferior quality or take away the shipment at his own expense, he is careful to meet the specifications at all times. It pays, therefore, to purchase from a contractor who has learned his lesson.

Coal should be purchased on a basis fixed by the value of the fuel to the plant and not on its British thermal unit or ash content. Coals giving good evaporation results may so clinker and slag as to be intolerably troublesome to burn. When coal is bought on an evaporative basis, therefore, the contract should contain a clinker and slag clause, besides those relating to slate and bone; otherwise a prolonged dispute will arise. It may or may not be possible to get a reduction in price, for the contractor has the advantage of having met specifications as to evaporation results. The contractor should, of course, have the privilege of conducting a test when disputes arise. The boiler on which a test is run should have the blowoff blanked and the feed water carefully measured in a calibrated tank or meter. The temperature must also be recorded at the tank or meter and at the entrance to the boiler, if economizers are used.

That the use of soft coal must continue to increase each year will readily be realized by a casual inspection of a map of the coal fields of this country, for a comparatively small spot indicates the anthracite fields. The supply being limited, the price keeps advancing which promotes the sale of soft coal.

Large manufacturers, especially those in manufacturing centers like Newark, N. J., might find it quite advantageous to buy their coal by specification through a joint committee. A testing bureau to check the quality of shipments by analysis could be maintained. Most plants could use the same grades of coals by slight changes in grates and boiler-room methods. The first year's saving would exceed the initial cost of the plan.

# Computing Thermometer Stem Corrections

By Charles M. Reed

*SYNOPSIS—With the aid of alignment charts thermometer-stem corrections may be obtained readily for both simple emergence and for calorimetric work where the difference in temperature is desired.*

During September, 1910, there appeared in Power a family of hyperbolas plotted to facilitate the calculation of the correction for the emergent stems of thermometers. The writer has applied the principles of the alignment chart to these calculations, and believes that this method will prove more convenient for use in everyday work.

For the benefit of those who may not be familiar with the stem correction, the following explanation and derivation of formulas is given:

Imagine a thermometer entirely submerged in some medium at a temperature $T$. Then, as thermometers are generally graduated for total submergence, the observed temperature $t$ will be the same as that of the surrounding medium, or $t = T$.

Now suppose that the thermometer is submerged only to some division $N$ with a part of the mercury column $t - N$ exposed to a cooler medium. The mercury, contracting because of the difference of temperature between the bulb and the stem, or $T - f$, will give a lower reading $t$ than the true temperature $T$. However, the glass in the stem also contracts, making the bore smaller, thus increasing the observed temperature $t$. The contraction in length of the stem will also apparently increase the height of the mercury.

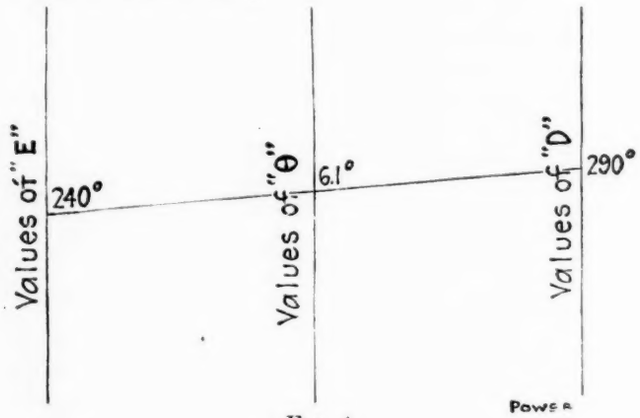



Fig. 1.

Now, let $E_M$ represent the coefficient of cubical expansion of the mercury for some range of temperature, and $E_G$ the coefficient for glass through the same range. Let $K = E_M - E_G$. Then the correction $\theta$ in degrees to be added to the observed temperature $t$ will be

$$\theta = K\ (t - N)\ (t - f)$$

The correction $\theta$ is to be added if the stem is at a lower temperature than the bulb, and subtracted if the stem is at a higher temperature than the bulb.

Scheel* has given, for the volume of mercury at a temperature $t$ degrees Centigrade, the formula

$$V_t = V_o\ (1 + 0.00018182t + 0.000000000078t^2)$$

which, when reduced to Fahrenheit units, becomes

$$V_t = V_{32}[1 + 0.00010101\ (t - 32) + 0.00000000043\ (t - 32)^2]$$

Applying these formulas, the average coefficient of cubical expansion of mercury is found to be 0.0001826 per deg. C., and 0.00010144 per deg. F. These coefficients apply for a range of 1000 deg. in each case.

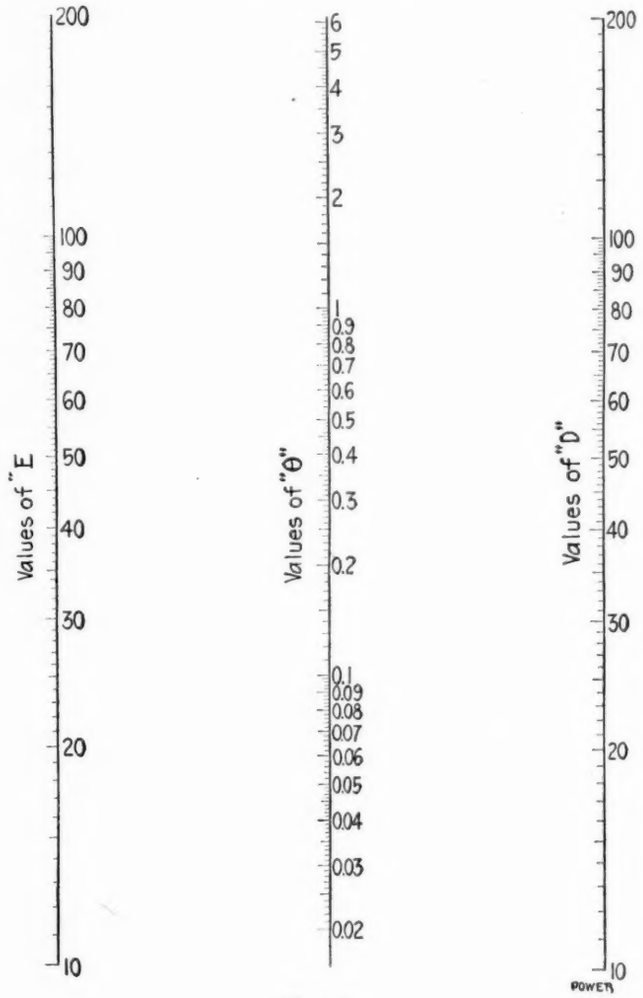



Fig. 2.

Reichsanstalt† gives the coefficient of cubical expansion of Jena glass as 0.00002533 per deg. C., which reduces to 0.00001407 per deg. F.

Then, for a Centigrade thermometer,

$$K = 0.0001826 - 0.00002533 = 0.00015727$$

say, 0.000157, and for a Fahrenheit thermometer

$$K = 0.00010144 - 0.00001407 = 0.00008737$$

say, 0.0000874.

Substituting these values of $K$ in the fundamental equation,

*Fifth revised edition, Smithsonian Physical Tables, p. 225.
†Fifth revised edition, Smithsonian Physical Tables, p. 224.

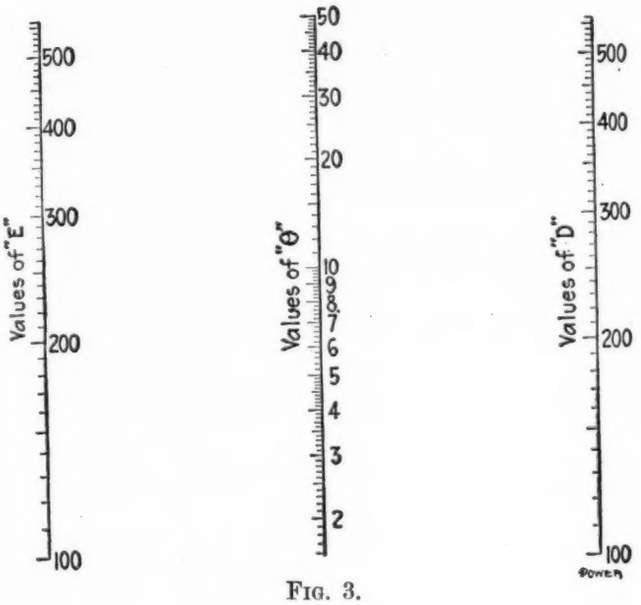



FIG. 3.

$\theta = 0.000157\ (t - N)\ (t - f)$ for a Centigrade thermometer

and

$\theta = 0.0000874\ (t - N)\ (t - f)$ for a Fahrenheit thermometer

For convenience, $E$ may be used in place of $(t - N)$, and $D$ in place of $(t - f)$.

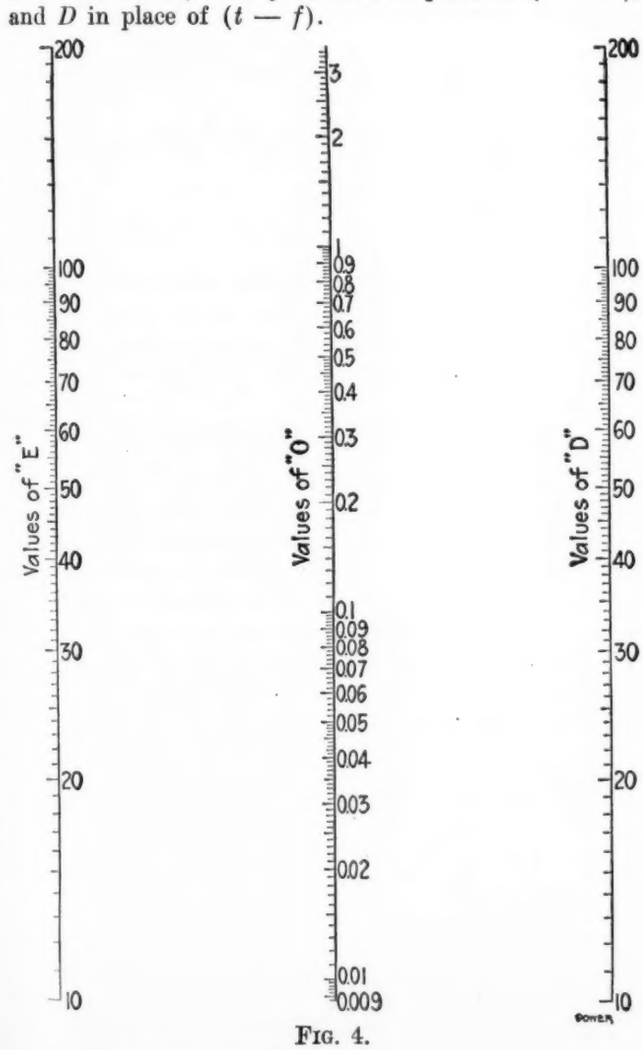



FIG. 4.

Now consider another case, that of calorimetric work, where the absolute reading of temperature is not desired so much as the difference between the initial and final temperatures in the calorimeter. Then comes the question: "What correction, if any, is required for the emergent stem in this case?"

This is just as simple as the preceding cases. For example, let the initial temperature be $t_1$ deg., final temperature $t_2$ deg., temperature of stem $f$ deg. and thermometer submerged $N$ degrees. What is the correction to be added to the differential temperature $t_2 - t_1$?

From the foregoing paragraphs it will be seen that at a tempearture $t_2$, the correction is

$$\theta_2 = K\ (t_2 - N)\ (t_2 - f)$$

while at $t_1$ it is

$$\theta_1 = K\ (t_1 - N)\ (t_1 - f)$$

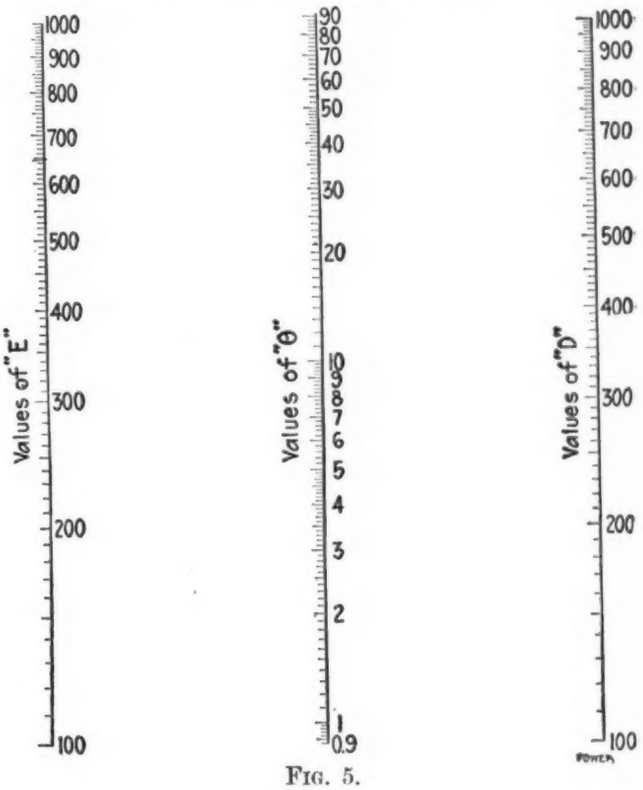



FIG. 5.

Clearly, the correction for the difference $t_2 - t_1$ will be $\theta_2 - \theta_1$. But

$$\theta_2 - \theta_1 = \theta = K\ [(t_2 - N)\ (t_2 - f) - (t_1 - N)\ (t_1 - f)]$$

Simplifying the above

$$\theta = K\ (t_2 - t_1)\ (t_1 + t_2 - N - f)$$

where $K$ is 0.000157 or 0.0000874 for Centigrade or Fahrenheit thermometers, respectively.

For convenience this equation may be written

$$\theta = KdX$$

in which $\theta$ and $K$ are as before,

$$d = t_2 - t_1$$

and

$$X = t_1 + t_2 - N - f$$

Fig. 1 illustrates the method of making the calculations; for example: Let $t = 390$ deg.; $f = 100$ deg. and $N = 150$ deg., then

$$E = t - N = 240\ deg.$$
$$D = t - f = 290\ deg.$$

and $\theta = 6.1$ *deg.*
for a Fahrenheit thermometer.

Figs. 2 and 3 are for Centigrade thermometers, the upper limit being chosen 560 deg., or approximately 1000 deg. F.

Figs 4 and 5 are similar to Figs. 2 and 3, but are for Fahrenheit thermometers.

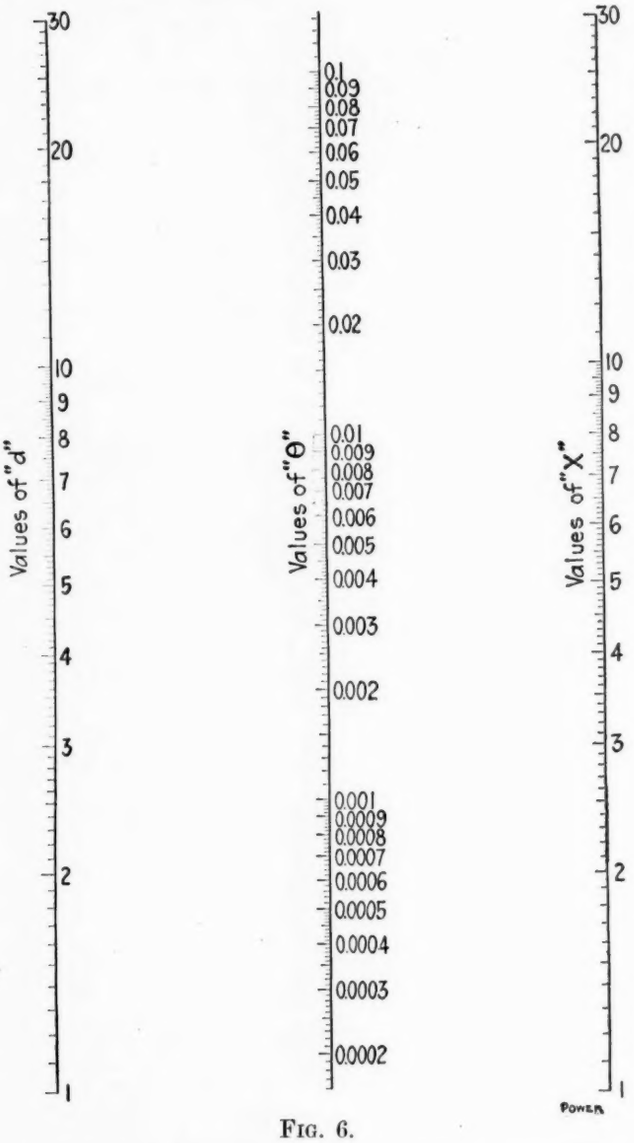



FIG. 6.

Fig. 6 is intended for use in making corrections for differential readings of temperatures. As most thermometers intended for calorimetric work are graduated in Centigrade degrees, Fig. 6 is for Centigrade thermometers, and no chart has been made for Fahrenheit thermometers.

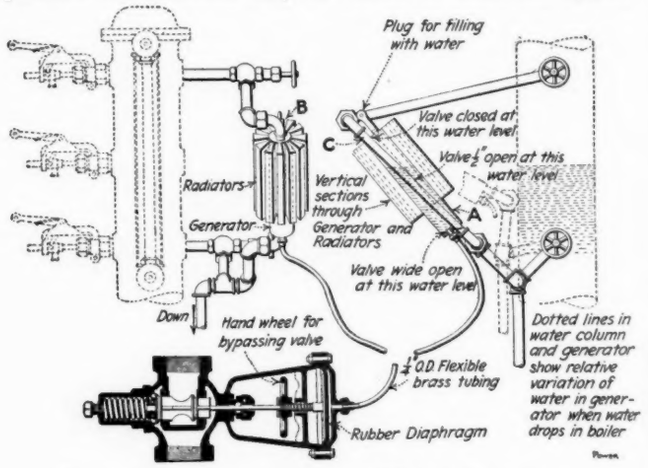
**Hydro-electric Fertilizer Plant**—American capitalists have purchased extensive water-power privileges extending along the Saguenay River from Lake St. John to tidewater in the Province of Quebec. It is said that some 300,000 hp. is to be developed at an estimated cost, for development of hydro-electric power and construction of plant, amounting to $60 or $70 per horsepower, to be used for the production of phosphoric-acid fertilizer in electric furnaces by heating phosphate rock (Florida pebble) with silica or sand. It is claimed that approximately 3 tons of 45 per cent. double superphosphate can be produced per horsepower per annum in the proposed plant.

## S-C Vertical Feed-Water Regulator

This feed-water regulator is designed to be attached to the water column of high-pressure boilers, to control the height of the water within certain limits and at the same time to give a continuous graduated feed.

The apparatus consists of a balanced valve made for pressures up to 350 lb., having an inserted Monel metal or nickel seat. This valve is operated by a rubber diaphragm, which works against a spring at the bottom of the valve disk, with cold-water pressure on the top of the diaphragm. The valve thus controls the discharge of feed water to the boiler.

The other essential features are the generator *A* and radiator *B*. The generator consists of a cylinder through which a ⅛-in. pipe-size tube *C* extends. The tube is connected to the water column or to the boiler by extra-heavy ⅜-in. nipples and fitting, so arranged that its position and location may be varied to meet the operating conditions. The tube is under boiler pressure, the lower part being filled with water to the corresponding level in the boiler. The space above the water is filled with steam through the top connection for the water column or boiler.


Plug for filling with water
Valve closed at this water level
Valve ½" open at this water level
Radiators
Vertical sections through Generator and Radiators
Generator
Valve wide open at this water level
Down
Hand wheel for bypassing valve
¼" O.D. Flexible brass tubing
Rubber Diaphragm
Dotted lines in water column and generator show relative variation of water in generator when water drops in boiler
A
B
C

DETAILS OF VERTICAL FEED-WATER REGULATOR

In the generator the space surrounding the tube is connected to the valve diaphragm by flexible, seamless brass tubing and is filled with water as shown. The water within the tube is exposed to radiation through the radiator *B*, and exposed to the heat of the steam in the tube. Any portion containing steam will be heated and will evaporate the water in the generator surrounding it into steam. The steam, being confined, drives the water through the connecting tube to the diaphragm, opening the valve in proportion to the amount of tube exposed to the steam.

Heat radiated through the thin walls of the generator assisted by the attached radiators, condenses the steam in the generator and reduces the pressure therein as rapidly as the tube fills with water. The spring on the reverse side of the valve moves the valve disk toward the closed position.

If the generator is placed vertically, the water in the boiler must drop 10 in. to fully open the 2½-in. valve, while if the generator is placed nearer a horizontal position, the valve will be fully opened in relatively closer levels. Under ordinary conditions, a 30- to 45-deg. angle

is desirable, as this position will carry a higher water level with light loads and will thus help on a peak load.

The regulator, manufactured by the S-C Regulator Co., Fostoria, Ohio, is said to give a constant feed and water level. As will be noted, the regulator is free from floats, pilot valves, weights and levers and its one moving part is the valve stem.

If the feed-water temperature is above 212 deg. F., or if the water is bad, an outside spring is used. An extension stem is secured to the valve disks, and by using a monkey wrench on the end unit the disks can be rotated against the seat, crushing any scale that may accumulate and cleaning the valve while it is in service.

# Power-Limiting Reactances

By John A. Randolph

*SYNOPSIS—Reactances as used to protect generating apparatus from heavy surges due to short-circuits. The operation, connections and construction of the principal types of such reactances are explained.*

The reactance coil in its various forms is extensively used on light and power systems to provide the impedance or choking effect necessary under certain conditions in which alternating or oscillatory currents are involved. It is commonly used on direct-current overhead lines in connection with lightning arresters and in this service is generally known as a choke coil. However, its most extensive and varied application is on alternating-current systems.

The principal uses can be classed under three headings: First, those employed in connection with lightning arresters and other protective apparatus; second, those used for voltage regulation in connection with compound-wound rotary converters, for giving stability to the operation of synchronous motors and to assist in tying stations together over lines of high resistance; third, those used with generators, feeders, busbar sections and auxiliary apparatus to limit the current which can be discharged into a short-circuit. This article will be devoted chiefly to the last class.

## Operation

The reactance coil accomplishes its purpose by reason of the back pressure which it exerts against alternating currents. This back pressure is known as inductance or the electromotive force of self-induction.* Its value depends upon the frequency of current reversals and the strength of the magnetic field. The latter depends upon the number of turns in the coil and the strength of current; in other words, the ampere-turns of the coil. The value of the electromotive force of self-induction is expressed by the equation

$$E_s = 2\pi f L C$$

in which $f$ is the frequency, $L$ the coefficient of self-induction and $C$ the current in amperes. From this it will be seen that the intensity of the electromotive force of self-induction in a given coil is dependent upon the strength and the frequency of the current. Hence the greater the current or frequency, or both, the greater will be the electromotive force of self-induction.

It is due to this action that reactance coils are able to keep out lightning discharges from the apparatus which they protect. The lightning is of a highly oscillatory nature and produces a counter electromotive force in the reactance coil so great that the discharge is forced through the lightning-arrester gaps to ground, the arrester gaps offering less opposition to the current than the impedance of the coil.

The effectiveness of the reactor in protecting apparatus against injury from short-circuits depends upon the fact that, as the resulting current assumes an abnormal value, the inductance of the coil also rises until it becomes so great as to keep the current from rising high enough to injure the apparatus. Reactors are so designed that, with the normal current flowing, the counter electromotive force is such a small percentage of the working voltage that only a comparatively small impedance is offered. However, with abnormal currents, the inductive effect assumes a value which enables it to greatly impede the current and thus to prevent it reaching a value high enough to cause serious injury. The short-circuit current of a generator not protected by a reactor may rise to 20 or 30 times the normal full-load current, depending upon the amount of impedance contained in the arma-

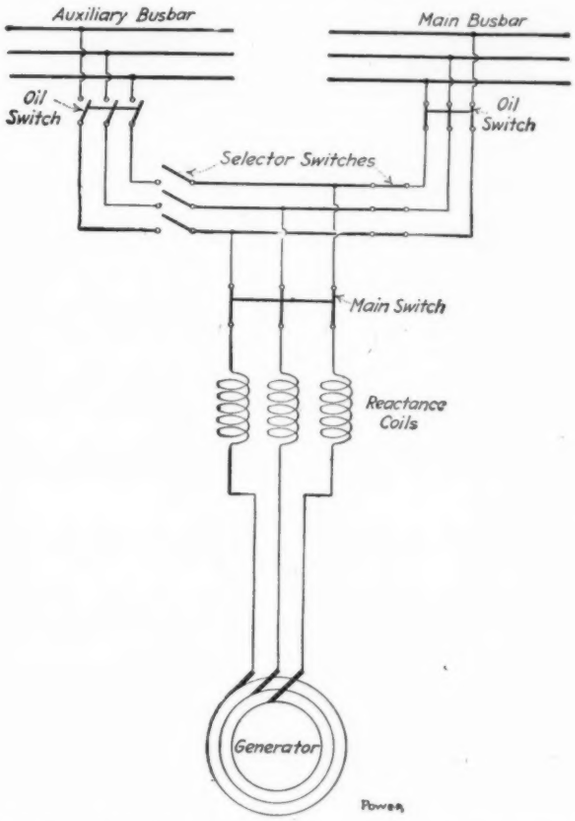



Fig. 1. Showing Reactances between Generator and Busbars

*See "Power," Feb. 24, 1914.

ture of the generator. With a properly chosen reactor connected to the generator, the short-circuit current will be reduced to less than half this amount.

The effectiveness of the reactor as a protection against surges may also be explained in the same manner as in the case of short-circuits; the heavy currents resulting from a surge increase the impedance to such an extent that damage is prevented.

### Uses

With the increasing capacity for which modern large generating stations are designed, the disastrous results

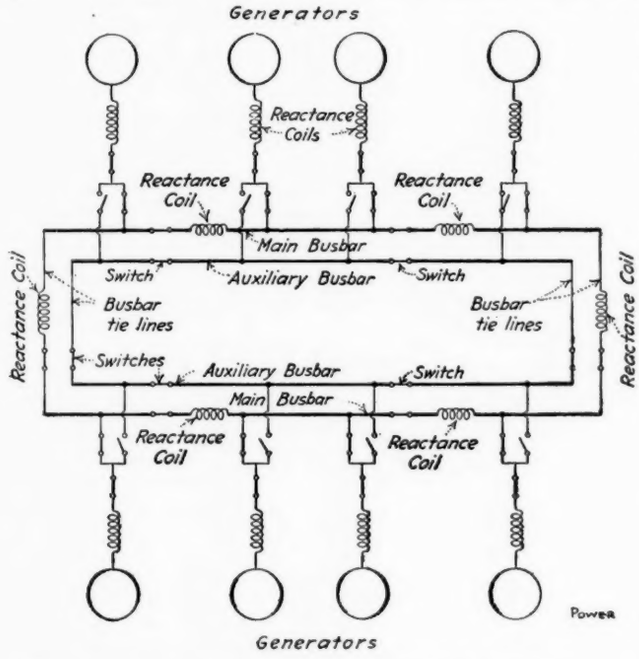



Fig. 2. Reactances between Busbar Sections as Well as between Generator and Busbars

of short-circuits have become more pronounced. With stations having a normal output of many thousands of kilowatts, the possible momentary discharge into a short-circuit, unless effectively checked, is almost unlimited. The automatic oil switches will open the defective circuit and stop the current flow if it is not too great. However, if the short-circuit be at or near the station, the current may assume such a value that opening of the oil switch will occasion a heavy surge and produce a high momentary rise in voltage. This may cause the current to jump to ground either at the switch or at some other point on the connected circuits. The arcing, upon the opening of the switch, may also be so intense as to seriously damage or ruin it. Moreover, the opening of oil switches requires a certain interval of time which, although short, may be sufficient to permit serious damage to generators and other apparatus. It is to avoid so far as possible such contingencies that the use of reactances at generating stations is now becoming the general practice.

Reactance in the various circuits may be provided in one of two ways or by both. It may be supplied by making the design of generators and transformers such that they will contain an amount of reactance sufficient for protection against short-circuits. This procedure may be commendable and give good results under certain conditions. However, it has been found, especially with large apparatus, that a reactance of more than 2 or 3 per cent. affects the regulation of transformers and by modifying the construction of the generator coils lowers the efficiency. Therefore, it is advisable to provide the extra reactance in the form of exterior coils. The amount of reactance of these coils is usually expressed as a percentage which represents the ratio between the reactive pressure at full-load current, and the voltage of the circuit.

### Connections

The connections of reactances to their respective circuits are comparatively simple, as they are always placed in series with the lines which they are designed to protect. Generator reactances should be connected between the generator and the busbars and on the generator side of the oil switch, as shown in Fig. 1. It will be observed that in case of a short-circuit on the busbars, feeder circuits, or any of the other machines, the generator will be protected by the choking effect of its reactor. On the other hand, if a short-circuit occurs in the alternator itself, the busbars will be prevented from discharging a heavy current into the fault, and thus wrecking the generator.

In Fig. 2 is shown the diagram of connections used between busbar sections and in busbar tie lines. In case of a short-circuit on any section, the adjoining sections are prevented from discharging their full capacity into the fault. Thus, not only is the apparatus protected, but a possible general shutdown is avoided.

### Construction

Reactance coils, while of comparatively simple construction, require careful consideration in design. In turbo-generators of large capacity the cross-section of copper required is so large that it is often impracticable to provide the necessary sectional area in a single conductor, owing to the difficulty of winding and also be-

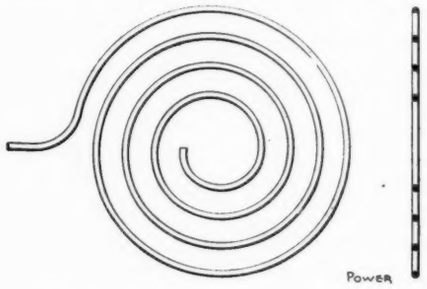



Fig. 3. General Form of Pancake Type of Reactor

cause of eddy-current and ventilating obstacles. These difficulties are avoided by providing two cables connected in parallel and placed side by side. The cables are stranded to reduce eddy currents and to render flexibility in winding. Bare or thinly wrapped cable is generally used to facilitate free ventilation, to make the overall size of the coil smaller than it would otherwise be, and to render the first cost as low as is consistent with good design.

In insulating the coil it should be remembered that the reactor may at any time be subjected to voltages far in excess of normal. The insulation must, therefore, be sufficient to withstand these strains. Moreover, in any

coil through which a current is passing a certain amount of heat is generated which causes a rise in the temperature dependent upon the proximity of the component turns, upon the strength of current and upon the ventilation. This is especially important in the design of large reactors. The conductor must, therefore, be so wound and supported that a free circulation of air can

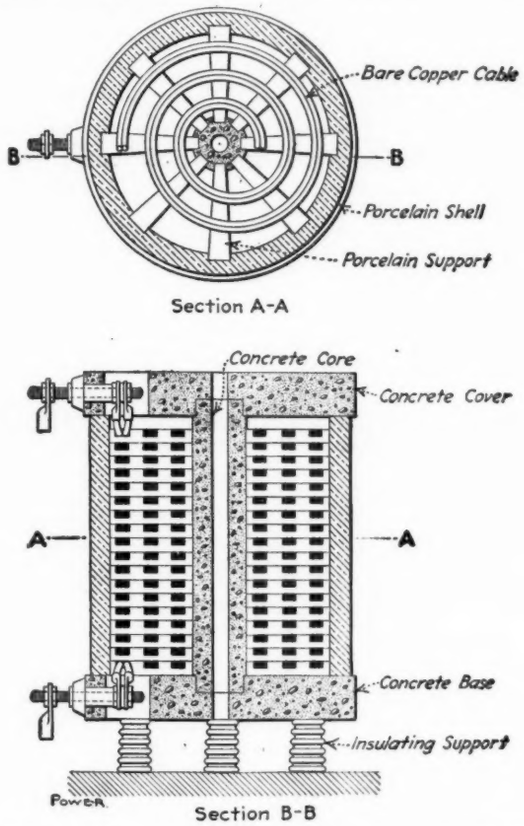



FIG. 4. SECTION AND PLAN OF PANCAKE TYPE OF REACTOR

take place at all times. To provide an insulation both electrically and mechanically secure and which will not be injured or affected by heat, porcelain, composition and treated wood are used, supplemented by asbestos or mica. The parts used for insulation must also serve as supports for the cables and must be sufficiently strong to withstand the mechanical stresses.

Another important feature is the heavy magnetic field induced in the coil and especially at a time of short-circuit. Iron cannot be used as a core for the reactor as it would become magnetically saturated in times of trouble and thus impair the efficiency. This is on account of the excessive size and weight that would be necessary. Furthermore, no magnetic material of any kind should be used in the construction of the coil and no metals of this nature should exist in close proximity to the reactor. For this reason brass is commonly used for tie-bolts, screws, fittings and connections.

## TYPES

In the construction of reactors two general forms are followed, the pancake and the drum types. By the pancake type is meant a coil whose layers are wound in planes perpendicular to the axis of the coil, as in Fig. 3. In the drum type the layers are of cylindrical form and are wound concentrically with the axis. An advantage claimed for the pancake type is that no two points of the reactor winding having a wide difference of potential are adjacent. This renders insulation easier and gives the coil a large factor of safety against mechanical and electrical stresses.

Fig. 4 is a form of construction used with reactors whose layers are of the pancake type. The cables are placed in slots in a series of porcelain arms arranged radially to the axis of the coil and held in place by the concrete core at one end and the outer shell at the other. The arms of the different layers are placed directly over those of the layers underneath in such a manner that they rest upon the latter, thus rendering the coil compact and mechanically secure against heavy stresses between layers. The outer porcelain shell serves both to insulate the coil from surrounding objects and to assist in the support of the interior parts as well. It is made up of segments, thus making it easy to assemble or take apart. The ends are of concrete and are perforated with radial slots to allow a circulation of air. The various parts are held together by brass tie-bolts fastened at the

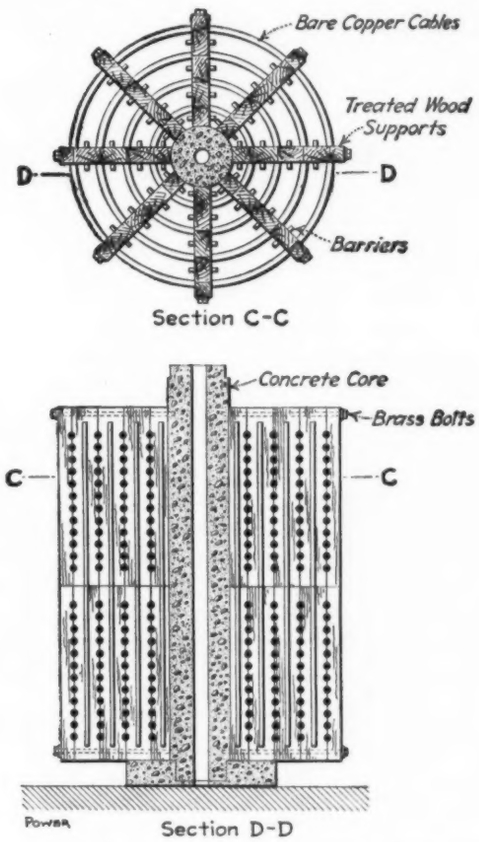



FIG. 5. DRUM TYPE OF REACTOR

ends to the top and bottom covers and extending through the outer shell. The cores are of concrete or alberene stone and are so constructed as to hold the radial supporting arms securely in place, at the same time allowing for up or down movement.

Another type of reactance which is widely used employs the drum type of windings, as in Fig. 5. The cables are held upon strong supports equally spaced radially to the axis and extending throughout the full length of the reactor. The supports are commonly made of treated wood. As a protection against heat and also as an added insulation, an asbestos covering is placed between the

cable and the wood. Wood barriers are fastened to the supports to afford a greater area of insulating surface between the respective layers. The supports are held in place by brass bolts fastened to nonmagnetic anchor plates in the core. The core is of concrete and has a longitudinal hole extending through the center as a convenient accessory for assembling or taking apart and also as an added feature of strength. It is a common practice in drum-type reactors to divide the winding into two sections so wound that the reactance terminals can be located on the outside of the coil without the necessity for a crossing or unsymmetrical arrangement of cables.

### Performance

Reactors under test have been found to reduce the short-circuit current on large generators to a value less than half what it would otherwise assume. Moreover, it has been found that when generators equipped with reactors were subjected to a full short-circuit, no damage has been sustained by the generator and its apparatus, although various voltages and conditions were used in the tests.

Reactors are now commonly used on generators, busbars, exciters, motor generators, transformers and to some extent on feeders. The percentage of reactance generally employed in the coils varies according to conditions. For exciters and motor generators it is usually low, being commonly between 3 and 4 per cent. For generators it usually ranges from 4 to 8 per cent., depending upon the output. Reactors placed between busbar sections and in busbar tie lines, owing to the large amounts of power involved, generally contain a comparatively high reactance the value of which is commonly about 18 or 20 per cent.

When once installed, reactors require but little attention, this consisting chiefly of an occasional inspection and removal of accumulations of dust.

# Moisture in Compressed Air

By Frank Richards

*SYNOPSIS—Free air always contains moisture, and practically nothing can be done for its removal until the air has been compressed, when troublesome moisture can be removed by draining it off as water; the higher the pressure the greater the opportunity.*

It is to be noticed that correspondents of Power are still inquiring about the way to keep the water out of compressed air and to prevent the freezing up of the exhaust passages of air-operated machines. This water and freezing-up trouble began with the earliest using of compressed air, and always must be encountered if the proper arrangements are not made to avoid it. Those of long experience with compressed air have generally learned, more or less completely, what it is necessary to do in the case, but as a second or a third generation of air users is now getting into the business, it seems to be necessary to rehearse the matter again, with occasional repetitions in the future.

### There Is No Dry Free Air

In the first place, practically nothing can be done until the air has been compressed. Carrying water is one of the principal functions of the air, and we never catch it that it does not carry more or less water vapor, mixed with it. The daily reports of the weather show that humidity is the most variable of the atmospheric conditions, being much more so than the temperature or the barometric pressure. But there is a lower limit of atmospheric humidity, far above the zero mark, which is never reached and seldom closely approached. When the humidity reaches 100 per cent. that becomes the "dew point," for the conditions then prevailing; the air can carry no more moisture in the form of vapor, the excess being immediately condensed into water, at first only minute globules, but still actual water.

Until the dew point is reached the air is perfectly transparent, and to the touch it is dry air; but when in the upward direction the dew point is passed, the condensed vapor is seen as mist, fog or cloud in the air, more or less dense, according to the amount of water liberated, and the air in this condition will wet, or at least dampen, whatever it may happen to touch.

The reason that the atmospheric humidity reports are so constantly varying is that the moisture-carrying capacity of the air is so dependent upon two constantly varying conditions: pressure and temperature, the latter especially. So far as the pressure alone is concerned, the vapor-carrying capacity of the air is almost directly as the volume, or inversely as the absolute pressure. Thus, if air is taken into a compressor at atmospheric pressure, say 15 lb. absolute, and at 50 per cent. humidity (though it is apt to be above that) then if the air is compressed to 15 lb. gage, or two atmospheres, its humidity becomes 100 per cent., and the air can carry no more water as vapor. If the same air is compressed to 45 lb. gage, 60 lb. absolute, or four atmospheres, then one-half of the vapor is condensed into water, and so on for other pressures. If the air we started with at 50 per cent. humidity was compressed to 105 lb. gage, 120 lb. absolute, or eight atmospheres, then only one-quarter of the original moisture could remain in the air as vapor, and three-quarters of it would be condensed into water. These figures will be referred to later.

We have gone along here, as theorizers are apt to do, considering only the one condition of pressure, or corresponding volume, and entirely ignoring the temperature. We could, of course, only have realized the results above predicted if the temperature had remained constant all through, which certainly would not have been the case.

If, now, we consider the temperature alone of the air under compression, we come to results quite different, and, we may say, quite astonishing. The capacity of air for vapor of water rises rapidly with increase of temperature. The following gives approximately the weight (lb.) of aqueous vapor per pound of atmospheric air at 50 per cent. of saturation and at various temperatures:

| Temp. Fahr. | Weight of Vapor per Lb. of Air | Temp. Fahr. | Weight of Vapor per Lb. of Air |
|---|---|---|---|
| 60 | 0.00547 | 140 | 0.07575 |
| 80 | 0.01099 | 160 | 0.14776 |
| 100 | 0.02127 | 180 | 0.32471 |
| 120 | 0.04020 | 200 | 1.13400 |

From these figures it will be seen that it requires a rise of only a little over 20 deg. F. to double the vapor-carrying capacity of air. From 60 deg. to 200 there would be seven of these doublings, or the vapor-carrying capacity of the air would have increased from 1 to 128. The actual increase shown is 1.1340 ÷ 0.00547 = 206, but this excess is accounted for by the much more rapid rise in the last interval between 180 and 200 deg.

It is to be remembered that the above figures apply to given weights, or actual quantities of air, and not to volumes. In compressing to eight atmospheres the vapor-carrying capacity, so far as volume is concerned, is only one-eighth of what it was before the compression, but with seven doublings of vapor-carrying capacity in consequence of the rise in temperature, the air still has 128 ÷ 8 = 16 times the vapor-carrying capacity which it had before the compression began.

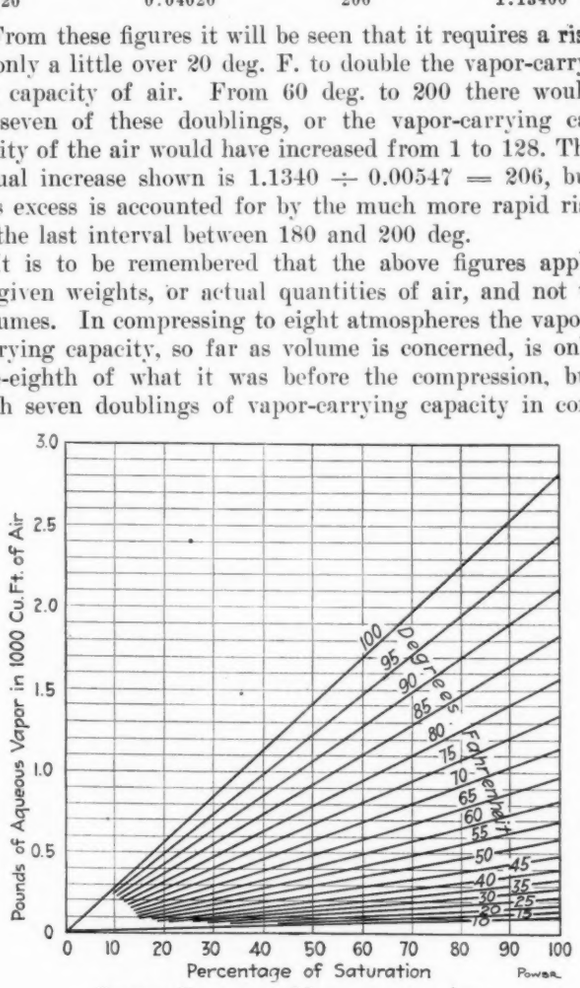



CHART SHOWING MOISTURE IN AIR

The case is more complicated than here outlined, because in adiabatic compression the volume during and at the completion of the compression is not reduced in proportion to the actual pressure increase; but, on the other hand, the temperatures are much higher than we have assumed, and it is evident that at the time of discharge the air must be really in a thirsty condition, although there has been no diminution of its vapor content.

In connection with the preceding, the diagram shown, will be found serviceable. It shows the weights of aqueous vapor in pounds per 1000 cu.ft. of air for practically the entire ordinary range of atmospheric temperatures and for different percentages of saturation, the latter being read horizontally at the bottom and the weights of water vertically at the side of the diagram. Each oblique line, or "curve," is figured for the temperature which it represents. The greater spacing for the higher temperatures, showing the increased water capacity, is quite striking. At 100 per cent. saturation, as also for any other percentage, the difference in the moisture content between 100 and 95 deg. F. is just equal to the difference between 45 and 10 deg., the latter difference being seven times as many degrees as the former. By extending the scale of temperatures upward, the differences would, of course, show much larger.

When free air is taken into a compressor at a normal temperature of, say, 60 deg., and is compressed to 105 lb. gage, the theoretical temperature is close to 500 deg., which temperature is much lowered if the compression be in two stages with efficient intercooling. If there is no aftercooler, it is doing well if the air is delivered at a temperature not above 200 deg.

The air now is in no condition to give up any of its moisture, and with the air receiver located near the compressor, the air is only slightly cooled, if at all, in passing through the receiver. There are those who continue to expect it, but they are continually disappointed.

### THE COOLING OF THE AIR

If, however, the air after leaving the receiver is transmitted through suitable pipes to a considerable distance, as it usually is, it is almost certain to be cooled to about normal temperature. The specific heat of air is low, so that when its temperature is high to the senses or to the thermometer it represents little in actual heat units and has little heat to surrender to its surroundings, even when cooling rapidly. With the air thus cooled in the pipes, both the conditions of high pressure and of low temperature will be the best possible for the condensation and release of the greatest possible amount of water vapor. With the temperature of the air the same as it was before the compression began, the temperature will no longer have any effect in increasing the vapor-carrying capacity, and with the volume of the air reduced to one-eighth of what it was at the beginning, its vapor capacity will be only one-eighth of what it was. If the air when taken in is at the point of saturation, or 100 per cent. humidity, then if the air is compressed to one-eighth the volume, seven eighths of the vapor can no longer be carried as vapor. If the air was taken in at 50 per cent. of saturation, then only one-quarter of the original vapor can be carried as such, and three-quarters of the vapor will be condensed, and so on for other pressures.

### DRAINING OFF CONDENSED VAPOR

When the saturation point is reached and passed, in consequence of a change in the combination of volume and temperature, the one being increased or the other reduced, then the air at once unerringly gives up all the surplus of vapor beyond what it can carry. That is, the vapor is condensed into liquid globules, but unless something more is done about it, the moisture will still remain in the air though in the liquid instead of the gaseous state. At the point of saturation, if the pressure were diminished or the temperature increased, some of the liquid would be vaporized again and become an intimate part of the air as before. If the conditions were reversed, the pressure being increased or the temperature reduced, more of the vapor would be condensed and the proportion of vapor remaining as part of the air would be reduced. On a summer day one may watch the clouds forming or gradually disappearing before his eyes as minute changes of pressure or of temperature occur.

The water condensed from vapor in the air, but still remaining in it in the liquefied condition, seems to be ready enough to get out of the air if given the opportunity. If compressed air just delivered from a com-

pressor and thus overloaded with condensed moisture, could be kept in a mass in a quiescent state, the water would slowly go to the bottom of the containing vessel; but it has no time to stop when passing through an ordinary receiver. If the air is in motion the liberated moisture it contains will wet and cling to whatever the air touches.

If the air in this super-saturated condition, due to high pressure and low temperature, is passed through a steam separator, of any of the types of proved efficiency, the entrained water will be taken out of the air just as it is taken out of wet steam. As the wet air flows along in a pipe line, the inner surface of the pipe will be wet, the water will trickle down the sides and flow along in a stream at the bottom. If there are low places in the line, and if pockets or settling chambers are provided at these points, the water will accumulate there and can be drawn off at intervals. If the water is not thus drawn off, it must be carried along bodily by the air at last into the drills, pneumatic hammers or other tools, and the neglect to drain off the water before the air comes to the point where it is to be used is the cause of most of the trouble of which complaint is made.

It is a natural and proper inference from the preceding that the higher the transmission pressure of the air, the greater will be the opportunity of draining it of moisture, and if the opportunity is taken advantage of, the less will be the possibility of trouble in the subsequent use of the air. With a system calling for comparatively low-pressure air, with single-stage compression and without aftercooler or separator or any provision for taking the water out of the pipes, the water will not allow itself to be ignored when it comes to the exhaust passages.

### Reheating Compressed Air

Nothing probably needs to be said of the theoretical economy and advantage of reheating compressed air before putting it to use. By reheating, the working volume of the air may be quite materially increased at slight cost and the freezing-up trouble may be annihilated. It must be remembered, however, that practically little reheating has been or is being done. For driving tools or machines which are only operated intermittently, and which have no fixed position, reheating of the air is not practicable and costs more than it is worth, but for the driving of pumps or for any other constant employment, the air should always be reheated as closely as possible to the work.

## How Englishmen Save the Auxiliary Exhaust

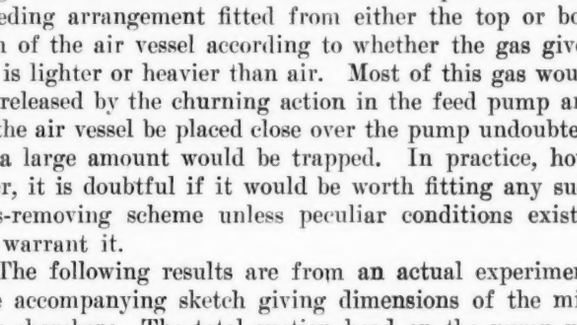
By E. R. Pearce

Since the turbine has been developed to its present reliable state, it is generally preferred to electric motors for auxiliary drive. It is much easier to keep up than some types of small engine, gives no more trouble than a motor to look after and, what is perhaps, most important, its reliability is greater.

Supposing turbines are adopted to drive the auxiliaries, and their exhaust naturally being free from all traces of oil, the point arises in the case of small stations as to the necessity of putting in a feed heater and storage, or carry the exhaust directly into the feed-pump suction line through the medium of either a suction condenser or exhaust-steam injector. Unless the lift is only 2 or 3 ft. a suction condenser should be used, the feed flowing to the point where the condenser is fitted if possible. In either case check valves must be fitted in the exhaust pipe to prevent water backing into the cylinder or turbine casing and also an atmospheric exhaust with suitable valves for changing over in case of necessity. Either of the above apparatus can be arranged in series or in single units, all exhaust being piped to them. Both devices are simple, require little attention and transfer all the heat in the exhaust steam to the feed water. To remove dirt and any scale-forming matter thrown down by the heating of the feed water, pressure-type filters may be used.

The only drawback to this arrangment arises in cases where a water gives off a large quantity of harmful gases, and these may be removed to a certain extent by fitting large air vessels with small automatic compressors and a bleeding arrangement fitted from either the top or bottom of the air vessel according to whether the gas given off is lighter or heavier than air. Most of this gas would be released by the churning action in the feed pump and if the air vessel be placed close over the pump undoubtedly a large amount would be trapped. In practice, however, it is doubtful if it would be worth fitting any such gas-removing scheme unless peculiar conditions existed to warrant it.

The following results are from an actual experiment, the accompanying sketch giving dimensions of the mixing chamber: The total suction head on the pump was 2 ft., the temperature of the exhaust steam 214.4 deg. F., the temperature of the inlet water 113.3 deg. F., the temperature of the discharge 129.5 deg. F., and the temperature of the outlet from the economizer 253 deg. F. The boiler pressure was 160 lb. gage. Under the above conditions the ¾-in. opening will pass 5.82 lb. of steam per minute. The weight of water 1 lb. of the exhaust steam would raise to the temperature of the discharge would




Sketch of Exhaust-Steam Injector

be 62.8 lb., and the total weight passed per minute would be 371.316 lb., or 22,279 lb. per hr. In this particular case the coal burned per hour was 3136 lb., so that the evaporation was approximately 7 lb.

Unfortunately the writer was unable to obtain the mean steam pressure in the pump cylinders, but the pump was a 9 and 5¼ by 10-in. duplex Worthington, making strokes of 8 to 9 in. at the time the above particulars were taken. One reason for the evaporation being so low was that the boilers were being forced and the economizers had only one-half the heating surface they should for a plant of the size.

The best results will be obtained when there is a head on the suction side of the pump, but in any case this will be one of the factors governing the maximum temperature to which the feed can be raised.

# Editorials

## Memorizing Plant Details

Loose-leaf books and card catalogs incline the operating engineer to acquire a rusty memory regarding dimensions, sizes of equipment and other plant statistics of secondary importance. While his ability to turn out a kilowatt-hour at a low cost is not affected by his reliance upon records for these details, it is well to keep posted enough to answer questions bearing upon the installation with what might be called a zero factor of hesitation. Individuals differ in their capacity to retain plant statistics. One can do it without effort, whereas an equally good engineer may find it hard to recall anything beyond the nominal horsepower of the boilers and engines and the height of the stack.

Some may ask: "What is the good of memorizing such data as the dimensions of the turbine and boiler rooms, the wattage of the lamps used, their height above the floor, the inside diameter of the chimney, depth of stack foundations, size of engine cylinders, capacity of circulating pumps, etc., when all such information can be had from a notebook?"

There are many advantages, apart from the saving in time. Perhaps the most important are the mental discipline and the evidence which the ability to give quick and accurate replies to questions of detail gives of personal efficiency. When the superintendent or manager calls the engineer to his office, he can take along his notebook, but it makes a better impression if he can answer every inquiry for information of more or less settled character without referring to it. Busy executives like a subordinate whose mind is cultivated to hair-trigger precision in delivering routine information. Such evidence of quick thinking and retentive powers shows the fitness of the employee for his job and leads to promotion. Visitors to his plant appreciate an engineer's ability to answer leading questions "off the reel," and many times this has been a factor in the receipt of offers from other plant owners.

Burdening one's memory with data of only trifling value is useless, but a live operating man should know the rating, speed and fundamental dimensions of every engine, turbine, pump, boiler, fan and motor on the place, the size of grate surfaces, capacity of stokers, number and size of tubes in the surface condensers, diameters of intake and discharge piping, length and height of circulating-water conduit, size of steam-delivery outlets at boilers, header sizes, span of the traveling crane, flue cross-sectional dimensions entering the stack, capacity of tanks, bunkers, ashpits, etc. It is the statistics of operating significance that are the most useful, rather than dimensions of trifling consequence, such as the clearances between various systems of auxiliary piping at various points or the overall dimensions of a feed pump. When these minor data are wanted, careful measurements or protracted studies of plans and elevations are necessary and there is plenty of time for them.

What the engineer needs to have at his command are data upon which such matters rest, as the rush ordering of spare parts, the comparison of bids, interpretation of plant performance, critical study of unit apparatus, rough estimates of the cost and desirability of plant changes or additions, fitness of new machinery for a trial on the premises, and other problems of executive concern. In the collection and study of such data and in the mastery of vital statistics hinted at as desirable, the ambitious engineer will find ample opportunity to put his mind to good use and to fit himself in part thereby for larger service and correspondingly increased remuneration.

## The Question of Boiler Rating

In the lecture on "Modern Boiler-Room Practice," by a member of this staff and printed elsewhere in this issue, a timely word of caution on the question of high boiler ratings is sounded.

We believe that Mr. Stott, of the Interborough Rapid Transit Co., is the pioneer in the practice of operating boilers at very high ratings. With him, it was necessary to meet the rapidly increasing steam demands on the Fifty-Ninth Street power house. He showed that this could be done without materially increasing the investment charges. On some occasions, the boilers in the Fifty-Ninth Street plant have been operated at ratings as high as three hundred and fifty to four hundred per cent. Since this demonstration of the feasibility of this practice, the profession has applied it extensively, especially in central-station and railway power houses.

In 1903 each 5000-kilowatt turbine in the Fisk Street station of the Chicago Commonwealth Edison Company was furnished steam by eight boilers, each with 5000 square feet of heating surface. Based on ten square feet of heating surface as equivalent to one boiler horsepower, there was a total of 4000 boiler horsepower to 5000 kilowatts. This gives 1.25 kilowatts per boiler horsepower. A little later the same boiler capacity furnished 12,000 kilowatts, or three kilowatts per boiler horsepower. At present the ratio is about one to three and one-half.

In the Two Hundred and First Street station, New York City, thirty-six, 650-horsepower boilers are expected to care for 110,000 kilowatts, or 4.7 kilowatts per boiler horsepower. At the Detroit Edison Company's new station, the stacks and breechings have been so proportioned that in emergencies it is expected that three 2365-horsepower (rated capacity) boilers will care for two 20,000-kilowatt turbines. This gives the very high figure of 5.65 kilowatts per boiler horsepower.

While indulging in enthusiasm over the benefits of high boiler ratings, it is well, as the lecture points out, to consider the dangers that accompany the practice. The factors that determine how much a boiler may be overloaded are first, the scale-forming agents and suspended solids in the feed water; second, the thoroughness of the

water circulation, and last, the amount of fuel which it is possible to burn per unit area of grate in a unit of time. The high overloads on marine boilers generally are contrasted with the usual loads carried by land boilers. It should be remembered that in marine practice the feed is mostly condensate and therefore free from scale-forming solids.

Some scale, when subjected to temperature variation, will crack off in places. When scale thus disengaged lodges on the tubes or shells of a boiler that is driven hard, serious bags usually result. At high ratings, the water boils so violently that scale, which may have become loosened, will sometimes be kept from contact with the shell or tubes, but when the boiler has ceased to steam rapidly, as when the peak load has passed and the fire is banked, the scale settles on the metal surface and the heat from the furnace walls and arches is sometimes enough to bag the tube or shell. Other tube troubles are the result of the effect of the blow-torch flame often produced in a fuel bed subject to high forced draft, the intensely hot flame impinging on one or a few tubes usually causes them to quickly overheat.

When high ratings are adopted, many forms of furnace trouble and repairs not anticipated will manifest themselves. High ratings have not yet become common in manufacturing plants, and before they do, let the engineers of these plants realize that where ratings of two hundred to three hundred and fifty per cent. are employed, the boilers are so operated for but brief periods, usually not longer than an hour and a half.

The aim should be, first, to install or use enough boilers to make it reasonably certain that one is not courting dangerous troubles. This means that the reduction of investment or overhead charges by practicing high ratings should always be governed by the consideration of safety.

## Coal Analysis

There is much written (and more said which would not look well in writing) on the subject of coal analysis and coal specifications in general. The ultimate consumer—the engineer or fireman—and the chemist do not get together and understand one another thoroughly. In fairness to both, it should be conceded that each is honest in his effort, competent in his line, and has just reason for complaint that he is not receiving the hearty support and coöperation of the other, but it is probably true that each expects too much and gets too little, like the guest who, in his endeavor to relieve the anxiety of the hostess as to the dinner, said: "It is first rate what there is of it, —er, I mean there is a great plenty such as it is."

The user says the chemist's test is all right so far as it goes, but that it does not go far enough, or that he cannot tell how coal from which a given sample is taken will behave under conditions which are not known to the chemist, while the chemist feels that the user's reports are quite abundant such as they are, but not thoroughly good.

The main reason, as stated before, is that they do not enter enough into the work of each other. The fireman struggling with a coal not suited to his equipment, and therefore unable to meet the peak-load requirements, cannot be expected to enthuse over the report of the chemist that the sample shows the coal of the best quality, etc. He cares nothing about the chemical content so long as the steam pressure is up, and less when the pressure is down. The chemist is too prone to swear by his results and the engineer at them.

The chemist should remember that his function is to tell the chief elements in approximately the percentages in which they are found, and when the most satisfactory combination obtainable is arrived at by experiment and trial under the boilers, he is to see that fuel of this composition is delivered so long as operating conditions remain the same. A closer coöperation between the chemist and the engineer will go a long way toward perfecting the system of purchasing coal by specification.

A practical chemist, speaking of oils, once told the writer: "I cannot tell you what chemical characteristics the oil should have for your plant, but if you give me a sample of an oil which has proved satisfactory, I can tell you what it is composed of and see that the oil you get in the future conforms to it. If later, the oil does not seem so good, you may find that the trouble lies in the bearings or elsewhere, and not that the quality of the oil has changed." This seems to be the crux of the matter. The purchase of fuel on the present basis is vastly better than the wrangle with the dealer as heretofore. Let us have a more complete test coupled with observation when it is in use.

## Accident Prevention

Another deplorable accident has happened in which two men were seriously and perhaps fatally scalded due to the prolific cause, a combination of inexperience and a hazardous occupation. Two men undertaking to clean a boiler, proceeded to remove the handhole plates before the boiler had been drained. "A torrent of hot water and steam gushed out upon them and the only means of escape was through a small opening." One became fastened and had to be dragged through.

Where lies the blame?

That the men themselves were at fault by reason of their negligence does not obtain if, as appears, it was known that they were inexperienced; if not known the fact might easily have been learned. It was obviously then the duty of someone to see that they were duly instructed and protected. Training men in their duties of whatever nature, in or about a power station, is the first essential to safety.,

Has the owner or his agent the legal or normal right to employ or allow an incompetent to jeopardize his own life or the lives of others? This question applies to all employments and positions in the plant. How is the employer to distinguish between the two? This forms the most complex problem and cannot be answered in such a way as to apply in all cases. But there is a vast difference between the known and confessedly incompetent and the man who, by reason of long experience, may be expected to do the right thing, but fails at some critical time. The deciding element too often is the wages for which the daily services of either can be obtained. Let there be more regard for human life.

Suppose, as the cartoon this week suggests, Hero, or Watt, or any other of the forefathers of steam engineering should return, like "Peter Grimm" and visit one of our modern power houses. They sure would be some surprised!

# Correspondence

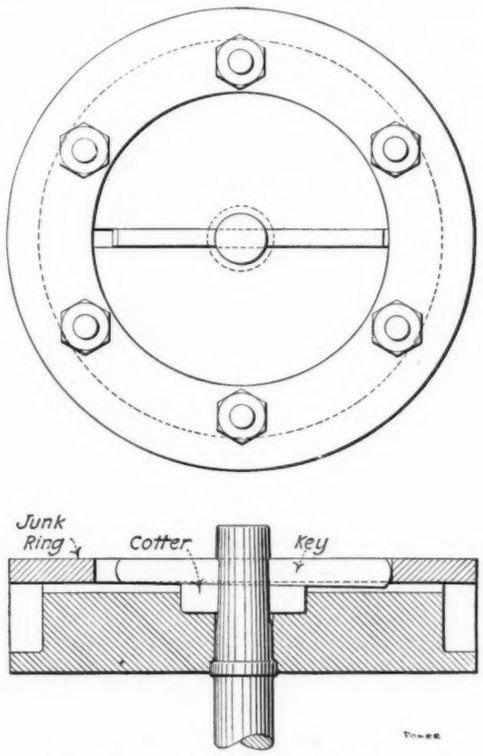
## Fitting Pistons

I cannot commend H. P. Clarke's method of shrinking and riveting on pistons, as stated in the Jan. 14 issue. There is always some doubt as to the holding power. Further, it is applicable only to the smaller sizes of pistons, and even then it is not applicable to a tandem engine. These opinions are based on experience with many pistons, varying in diameter from 4 to 108 in.

I have always used one of the two following ways, favored by most engineers here, for securing the rod. For pistons up to 48 in. in diameter and having junk rings, tapering the rod, forming a shoulder and fitting a key and cotter, both of which are prevented from working out by the junk ring, as shown, are common and good practice. The junk ring must be taken off before the cotter and key can be removed.

The second method is to taper the rod and fit a steel nut having a castle head. The nut is prevented from turning as the split pin fits in a recess in the nut.

If the piston has, say, a couple of 1-in. holes drilled and tapped on each side of the piston eye, it is an easy




Old Method of Fitting Pistons

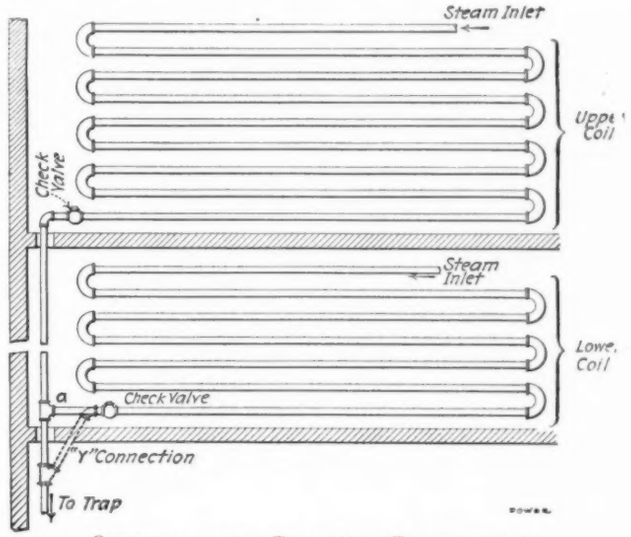
matter to remove the piston by placing a heavy plate across the end of the rod (after removing nut and cotter) and using two long studs extending through the piston and the plate on the end of the rod. By putting a fair amount of tension on the plate, the piston will come away; if it happens to stick, a few heavy blows on the plate while the tension is on will be sufficient usually to start the piston. When a piston is well shrunk on the rod it is nearly impossible to get it off.

E. R. Pearce.

Rochdale, England.

## A Troublesome Steam Coil

There were two drying rooms or ovens situated on above the other, each containing 1500 ft. of 1-in. pipe arranged on the sides of the rooms in the form of a box coil. Both ovens were connected to the main steam line carrying 150 lb. steam pressure, with a common return




Original and Changed Connections

line to a trap, of the tilting type, located in the basement. The lower coil gave trouble; it would not drain properly, so that it was nearly always half filled with water, and the desired temperature could not be maintained in the oven.

I found that the coil was not air-bound, and that the trap was of ample capacity and working properly, so I traced out the drain-pipe lines and found them connected as shown in the sketch at *a*. After substituting a *Y* for the *T*, as shown by dotted lines, both coils worked satisfactorily.

C. E. Anderson.

Chicago, Ill.

## Ill Advised Winding Changes

With an electrical machine of good design, which the operator has in no way undertaken to modify, the possible troubles are limited. If simple tests fail to disclose anything the matter with the machine itself, one may look to defective indicating instruments, overload, excessive voltage or some characteristic of the connected load.

A direct-current motor driving a centrifugal blower,

gave commutation trouble that seemed to be due to the commutator distorting and to its bars becoming loose. Naturally the commutator was blamed and a new one was installed; but in a few days the new one gave the same trouble. A good commutator man, not supposed to know anything about general testing, diagnosed the trouble as due to excessive speed and proved his case by taking the speed with the bypass on the blower closed. All previous speed tests had been made with the motor under load and without observing the relation between the speed and the load. The so called full-load speeds, which had not proved excessive, were revealed to be really the speed corresponding to heavy overloads. At normal current load, the speed was actually 35 per cent. high and on no load the motor almost raced.

It seems the operator wanted to "speed the motor up a little," so he rewound the fields with a smaller size of wire, thereby not only producing excessive speed, but otherwise impairing the motor's commutation characteristics.

Schenectady, N. Y. J. A. HORTON.

## What Did the Engineer Get?

In the Mar. 10 issue, page 349, Warren O. Rogers cites a case where "Engineer Wise," on taking charge of a plant already in operation, saved his employers $135.20 per week, or $7030.40 per annum by changing the grade of fuel, making changes in machinery, etc. I wonder how much of this amount was added to the engineer's salary over and above what was paid by his employers to the man who preceded him in the plant.

It may seem sordid, but an experience covering many years has caused me to think it is as much the duty of an engineer to look after the condition of his own pocketbook as of that of his employer's. How about it?

Yonkers, N. Y. W. H. ODELL.

## Condenser Temperature and Pressure

It is well known to engineers that in any condenser the temperature of the air-pump suction is a few degrees below the temperature of the steam as it enters the condenser from the exhaust pipe. This difference is 30 deg. F. in some cases, and though sometimes mentioned in textbooks is but rarely explained; it is due to the impossibility of keeping the condenser absolutely free from air leaks.

The explanation of why the presence of air affects the temperature is as follows: Let it first be assumed that the pressure throughout the condenser is constant (it is practically so within small limits) and that the condenser contains a mixture of air and steam in a certain ratio. Dalton's Law of Gaseous Pressures states that the pressure of a mixture of gases is equal to the sum of the individual pressures of the gases which would result if each were to occupy the entire space alone. Hence, the pressure in the condenser is made up of the pressure due to the steam plus the pressure due to the air.

The entering steam consists of a mixture of water vapor and air in a certain proportion, but as soon as some of the water vapor is condensed the proportion of air to vapor is raised. Hence, the pressure due to the air increases while the pressure due to the water vapor diminishes, and this decrease in vapor pressure is accompanied by a corresponding fall in temperature.

For example, suppose there is a condenser pressure of 3 lb. per sq.in. absolute; 2 lb. per sq.in. being due to steam and 1 lb. per sq.in. to the presence of air. The steam temperature corresponding to 3 lb. per sq.in. absolute is 141.5 deg. F., while the actual temperature corresponding to a steam pressure of 2 lb. per sq.in. absolute is 126 deg. the final temperature is therefore 15.5 degrees lower than would be the case if the entire pressure was due to steam alone.

Glasgow, Scotland. JOHN H. GEO. MORRISON.

## Writing Specifications

Writing specifications of all power-plant supplies or parts of any kind is one of the best educational exercises possible. It is also of practical use. As a test of how much or how little attention is given to the details of any familiar object seen daily in the power plant, let the reader undertake to write, without consulting a book or a catalog, a complete, binding specification. A specification must hold even an unscrupulous bidder to exactly the thing wanted. It should avoid "freak" conditions or requirements, which if actually specified, would mean additional cost to manufacture and useless expense. Then let him compare what he has written with standard specifications and see how far short he falls.

Try something easy at first, for example, a cast-iron flanged fitting 14x8x10, with companion flanges covering the following in full:

1. Articles called for:
   - Number
   - For what pressure
   - For what temperature
   - What material:
     - a Cast iron
     - b Semi-steel
     - c Cast steel
2. Test:
   - a Kind of test
   - b Pressure of test
   - c Weight limits
   - d Thickness limits
   - e Where made and by whom
   - f By whom paid for
   - g Causes for rejection
   - h Fillers allowed or not
3. Delivery:
   - a When
   - b Where
   - c Whose expense
   - d Final acceptance
4. Dimensions:
   - a Face to face
   - b Face to center
   - c Diameter of flanges
   - d Diameter of bolt circle
   - e Thickness at bolt circle
   - f Number of holes
   - g Drill size of holes
   - h Position to center line

   Packed joint:
   - a Rough or smooth cut
   - b Plain or raised face
   - c If raised, diameter and height of face
   - d If male and female, diameter and height of male; diameter and depth of female
   - e If tongue-and-grooved, outside and inside diameter and height of tongue; outside and inside diameter and depth of groove.
5. Flanges:
   How to be attached to pipe:
   - a Thread tapered or straight.
   - b For standard, extra heavy or double extra heavy pipe
   - c Kind of thread, pitch and diameter
   - d Screw joint
   - e Screwed and peened in thread
   - f Screwed and peened into chamfer
   - g Shape and size of chamfer
   - h Thickness of flange at thread
   - i Peened without thread
   - j Diameter of bore, shrunk or slipfit
   - k Thickness on pipe
   - l Chamfer shape and size
   - m Calking recess—depth, large and small diameter
6. Bolts:
   - a Size
   - b Length
   - c Kind of head, hex. or square
   - d Kind of nut, hex. or square
   - e Finish

While the foregoing appears formidable on first sight, it is in fact implied if not specified in any order for such a fitting; therefore if the fittings are wrong, it may be due wholly to lack of detailed specifications.

If the whole power plant is gone over in this manner, it will be a complete analysis which may never have been thought of before.

When something new is to be ordered, write a specification of it carefully and completely and there will be less to cause contention and dissatisfaction. Try it and see how well it works out.

LEON LEWIS.

New York.

## Long Service of Gas-Engine Piston Rings

In our plant of four Westinghouse gas engines, which have been in constant service for 12 years, we recently had the cylinders of two of them rebored and fitted with new pistons and rings.

The last of the two to be rebored was a vertical three-cylinder engine, 14x18 in., and rated at 175 hp. One cylinder was in bad condition, having been scored, and it usually began to give trouble if a heavy load was put on it, while the left-hand cylinder has given unusually good service, the piston not having been out for about ten years until it was removed recently to rebore the cylinders.

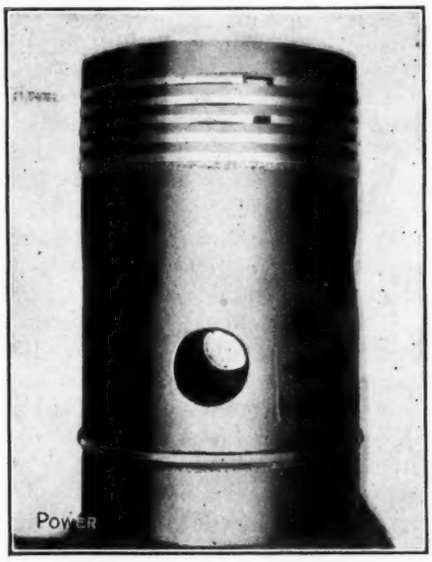



FIG. 1. PISTON AS IT CAME OUT OF CYLINDER

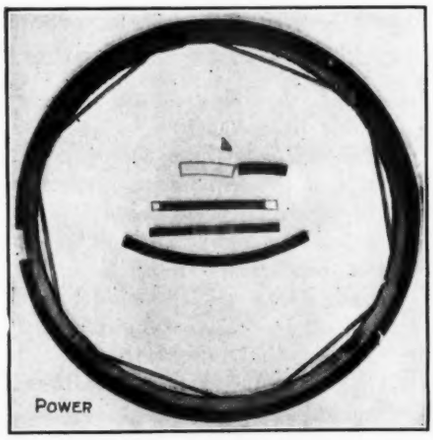



FIG. 2. OLD-STYLE SEGMENT RING

Fig. 1 shows the piston as it came out of the cylinder with the rings in place without disturbing the carbon deposit; all of the outside sections were free and could be moved around but were worn thin. The inner segments were held in the groves by the carbon deposit, but the carbon was not hard as it could easily be scraped out with a screwdriver. The piston had never shown any signs of blowing by the rings.

Fig. 2 shows one of the old-style spring segment rings found on the piston, showing it just as it was removed from the cylinder without the carbon deposit being disturbed; this can be seen on the inside of the segments. This type of ring has been obsolete for years, as it usually got carbon bound much sooner than any other type, especially if a poor grade of oil was used. In the center of Fig. 2 are three views of broken pieces of the outside ring.

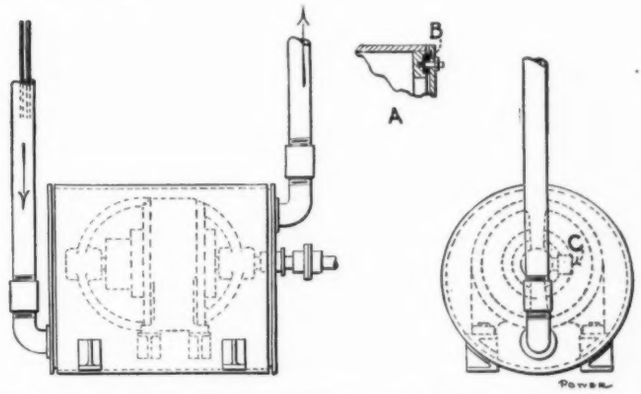
During the first eight years' service of this set of rings the engine ran six days a week and 16 hr. each day; the last two years the set has been in service every other day for the same number of hours each day.

L. M. JOHNSON.

Emsworth, Penn.

## Submerged Motors

Motors built for submerged service are usually of special design and are large for their output in order that excessive heating may be avoided; these features make the cost high.




CASING FOR SUBMERGED MOTOR AND DETAIL OF JOINT

The arrangement here described employs a motor of the standard floor type, no changes being necessary in the patterns or in any of the windings; hence a quick shipment is easily made. The tube inclosing the motor is of thin sheet metal and rests on cast feet welded to it. Cast feet are also placed inside the tube upon which the motor rests, being welded to the tube in order to avoid bolt or rivet holes. A stuffing-box is provided where the shaft extends through the rear-tube cover.

The tube ends are of sheet metal and are fastened, as shown in detail at *A*. A bar of rectangular section is bent into a ring and then welded to the tube. Into this ring is turned a groove to receive the packing *B*. Studs and nuts are used, and to avoid possible leakage, the stud holes are not drilled through the ring. Attached to the

covers or ends are iron pipes through which air is forced to the tube, insuring good ventilation of the motor. The air enters at the commutator end. The wires leading to the motor are inclosed in one of the pipes, so that no water comes in contact with them.

In order to insure good lubrication for long periods without the attention of the operator, an oil reservoir has been provided in addition to the regular one cast in the bearing housing. This additional oil chamber, shown at *C*, consists of a plain, closed cylinder, piped to the oil reservoir in the bearing housing.

Machinery of all kinds is invariably tampered with while idle by persons mischievously inclined, and electric motors are no exception. Such tampering would render an equipment useless at a time of emergency. By entirely inclosing the motor this nuisance is avoided, especially where the motor is not continually submerged.

G. F. WEIGAND.

Elizabeth, N. J.

## Fairness to Understudies and Successors

Referring to your editorial on this subject, in the Mar. 10 issue, I am sorry that retiring engineers, whether they leave from choice or otherwise, frequently do give their successors all the trouble they can. Probably their idea is that, by so doing, they magnify their own importance. However, it is a poor policy and sometimes acts as a boomerang.

Some years ago the engineer of a drug mill left to take a situation at more pay, and his former employers got another man. The new man went to the factory on Sunday and, as the engineer who was leaving did not come near, he looked over the plant alone until he thought he had it well in hand. The plant consisted of a 12x24-in. engine and a boiler to correspond. The engineer did his own firing. The engine was of an old type, having poppet valves operated by a cam shaft parallel with the cylinder.

During the following morning, the firm I was with got word that there was something wrong with the engine, as they could not keep up steam, and I was sent to investigate.

When I got there, the engineer, a stranger to me, was doing his best in the fire pit, but the engine labored hard. I looked it over and found nothing hot. Then I went through the three-story factory but found nothing until I got on the roof and saw the exhaust. I knew then that the trouble was at the engine, and my first impression was that the former engineer had tampered with the piston.

While waiting for noon to make an examination, I noticed that the rollers on the end of the poppet-valve levers continued to roll even when the concentric part of the cam was passing, instead of clearing it. Evidently the rollers on the valve levers had been lowered enough to prevent the valves seating properly, thus causing continuous blow. As soon as I raised the rollers to clear the concentric part of the cams, the engine bounded to its work.

The new engineer was a good man, and no doubt would have discovered the trouble himself, but for the fact that he had to do his own firing and had no time for anything else until noon. To my mind it is mighty small business for a retiring engineer to play such a trick either maliciously or as a joke.

L. S. WILLIAMS.

Philadelphia, Penn.

## Removing Frost from Direct-Expansion Coils

Relative to the discussion on this subject, and to the letter by A. G. Solomon, in the Mar. 17 issue, I offer the following:

Ammonia cannot condense and evaporate as it pleases without the transfer of a lot of heat. If hot gas is admitted to a cold coil, the gas will condense only after it has given out from 550 to 600 or more B.t.u. per pound, the exact amount depending upon the temperature and the pressure. One pound of hot ammonia gas will melt about 4 lb. of ice before all of it will be condensed. If liquid at 90 deg. F. is admitted to the coil, 1 lb. will melt about $^{5}/_{11}$ lb. of ice in cooling to 32 deg.—that is, it takes about nine times as much liquid as gas to do the same thawing.

Mr. Solomon's argument about the machine doing no work on the other coils because of lack of ammonia, was evidently got from experience in thawing frost with liquid, as a large quantity would be required; he would also have trouble getting that liquid out of the coils again. Mr. Solomon should be sure he did not drain the receiver of all liquid and then let gas into the coil through the expansion valve and thaw with the gas.

It is the same old notion, but in another form, that it is all gas beyond the expansion valve and that gas does the cooling. If it is proper to cool with gas, use liquid for heating. It is the change of state that gives out or absorbs heat. Changing from gas to liquid gives out heat; changing from liquid to gas absorbs it. The ammonia and steam condensers and steam radiators give out heat; the cooling coils and a steam boiler absorb it. The quickest and best way to thaw ice off a coil is to operate that coil temporarily as a condenser by supplying it with hot gas instead of with cold liquid, as in regular operation. As a consequence, long before the coil is full of liquid the frost will be melted off, or if very heavy, will be loose from the pipe and can be rattled off with a stick without danger to the pipe or the fittings. A good scraper will do the work, but it is more work and takes longer.

HARRY D. EVERETT.

Fort Snelling, Minn.

## A Troublesome Engine Click

After an engine had been down for a general overhauling and was again started, a peculiar knock developed. It differed from the usual pound in being more of a metallic click. The engineer failed to locate the trouble beyond deciding that it must be in the cylinder.

He took the head off and found no clue, but on replacing the head he put a layer of thick paper over its surface, which changed the sound to a dull thud. On again taking the head off he found a slight indentation in the paper which showed that one of the nuts on the piston stood out farther than the rest. This nut was filed down, ending the trouble.

SIDNEY K. EASTWOOD.

Philadelphia, Penn.

# Inquiries of General Interest

**Piston Ring Diameter**—For a 14-in. diameter cylinder how large should the ring be turned?

M. O. D.

The ring should be 14¼ in. in diameter before it is cut and sprung into the cylinder.

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**Poppet Valves**—Why are poppet valves used on some large engines?

M. O. D.

Poppet valves are used because they can be made as balanced valves, and are readily operated to give a sharp cutoff.

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**Increasing Power of Engine**—How can the power of a steam engine be increased?

G. J.

The number of horsepower which the engine can develop may be increased within the working capacity of its parts, by increasing the speed of the engine, or supplying the engine with steam at higher initial pressure, or by reducing the back pressure, as by use of a condenser.

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**Boiler with Superheater**—What precaution should be taken in starting a boiler with a superheater?

M. O. D.

In starting up a boiler with a superheater, start up with the superheater "flooded," allowing the water level to lower gradually before the boiler and superheater get into regular use.

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**Dead Power Factor Meter Reading**—When there is no current on the instrument where will the pointer of a power factor meter stand?

A. T. S.

As most pointers are mounted on jewels without springs, it will stand wherever it happens to be when the current is turned off.

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**Compound Engine Exhaust Pressure**—If the cylinder ratio of a compound engine is four, and the cutoff at one-quarter of the stroke in the high-pressure cylinder, what will be the absolute terminal pressure in the low-pressure cylinder?

M. O. D.

Without allowing for drop or clearance it would be one-sixteenth of the absolute initial pressure in the high-pressure cylinder.

---

**If the Governor Belt Breaks**—If an engine governor belt should break would the engine run away or stop?

J. G.

Unless the engine is provided with an automatic stop valve or the governor itself is supplied with an automatic stop motion, more steam will be admitted to the engine than is necessary to keep up the proper speed and the engine will run away.

---

**Height of Siphonage**—What limits the height to which water will rise in a siphon?

B. A. N.

The water is forced upward in the rising leg of a siphon by the pressure of the atmosphere acting on the free surface of the water. The water will rise until the pressure due to the height of the water in the rising leg of the siphon and the pressure at the top of the siphon are together equal to the pressure of the atmosphere.

---

**Aligning an Engine**—How may a horizontal engine cylinder be squared with a line shaft in a building?

M. O. D.

Draw a line through the center of the engine cylinder, or parallel to the center line of the cylinder, and place the engine so that such a line will be square with a line stretched level and plumb under the center line of the line shaft at the same level as the cylinder center line, or the line which has been stretched parallel to the cylinder center line.

---

**Beveled Safety Valve Seat**—What is the advantage of having the seat of a safety valve beveled at an angle of 45 deg.?

M. O. D.

The advantage is that as soon as the valve lifts from its seat, a larger area is presented for the pressure of steam to act on the valve, thereby compensating for the reduction in pressure right at the point of release of the steam. Another advantage is that the valve and its seat do not wear away so rapidly, and the valve will thereby be kept tight longer.

---

**Saturated Steam From a Superheated Supply**—If a battery of boilers were fitted with a superheater and the whole output of steam were to be taken from one main pipe, how could one particular engine be supplied with steam that is not superheated?

M. O. D.

The steam for that particular engine could be carried off separately through an uncovered pipe and allowed to lose its superheat, if desired, before the steam is supplied to this engine, thereby reducing the steam to the condition of ordinary saturated steam.

---

**Velocity of Pump Discharge**—On page 314, Mar. 3 issue, is given a formula for figuring the velocity of a pump discharge against 80 lb. pressure. How could the velocity be calculated for other pressures?

D. F. B.

The mention of 80 lb. pressure was superfluous beyond indicating that the water pumped is a homogeneous liquid. Considering water as an incompressible liquid, for a given rate of pump displacement, the velocity or speed attained by the liquid when pumped through a given size of pipe would be the same for all pressures.

---

**Furnace-Lining Trouble**—The side walls of our boiler furnaces burn out very quickly down next to the grates. What causes it?

J. W. D.

If burning out of the firebrick is due to the material of the brick, as, for instance, presence of sand melting to glass, the trouble may be detected by examining whether slag has formed within the brick. If slag forms only on the furnace face of the firebrick, it is probably due to presence of silica (sand) in the coal or mixed with the coal. If the brick crumbles with a clean fracture the crumbling is due to expansion of some material or substance in the pores of the brick, probably water due to moisture in the brick when laid, or afterward absorbed.

---

**Unit of Evaporation and Factor of Evaporation**—What is meant by the terms unit of evaporation and factor of evaporation?

J. D.

The unit of evaporation is the common standard to which the results of boiler performances are compared, being the heat required to evaporate 1 lb. of water from a feed-water temperature of 212 deg. F. into steam at the same temperature, which, according to standard steam tables, is equivalent to 970.4 B.t.u. A factor of evaporation is the quotient which results from dividing the number of heat units necessary to evaporate 1 lb. of water under actual conditions of feed-water temperature and steam pressure, by the heat equivalent of a unit of evaporation, i.e., by 970.4 B.t.u.

---

**Resetting Pump Rod Spool**—If a spool slips on a pump rod how should it be reset?

M. O. D.

Move the piston rod of the side which carries the spool so the steam piston on the same rod strikes one end, and then move it so it strikes the other end, each time making a mark on the rod even with the end of the stuffing-box. Next find a point midway between the marks and move the piston rod into the cylinder until this mark comes even with the end of the stuffing-box. The piston will then be in the middle of its stroke. Then remove the valve-chest cover and set the rocker so that when the rocker arms and the valve rod of the opposite side of the pump are standing still the "lost motion" will permit the valve to be moved as far to one side of its central position as the other. When this condition is satisfied the spool will be in its right position on the rod, and can be fastened in place.

# Engineers' Study Course

## Elementary Mechanics--IV

### Last Lesson's Answers

11. When a body is regarded as acted upon by forces only it is called a "free body."

12. Yes.

13. Yes.

14. The conditions of equilibrium are that (1) the resultant = 0; (2) the summation of the horizontal components = 0; and (3) the summation of the vertical components = 0.

15. In Fig. 13 the force $P_1$ represents the force exerted by the steam on the piston, transmitted through the piston and connecting-rods, to the crankpin. The force $P_2$ might represent either the weight of a flywheel, or the rotating field, or armature, of a generator. The forces $R_1$ and $R_2$ represent the reactions offered by the main bearings, and the force $P_3$ could be either the weight of a pulley, or the weight of a flywheel, depending upon the type of engine and the nature of the load.

### Equilibrium Continued

If the three conditions of equilibrium, as stated at the close of last week's lesson, are thoroughly mastered by the student, but little trouble will be experienced in dealing with forces which produce a state of uniform motion or rest of a body. Referring to Fig. 10 in Lesson III, the force $T$ is the resultant of $OM$ and the force $P$, but this resultant $T$ is balanced by the corresponding reaction of the crankpin on the connecting-rod. Therefore, since the forces are all in balance the resultant must equal 0. To find the force, then, required to balance a system of forces it is necessary (1) to isolate all the forces from the body on which they are acting, (2) to resolve these forces into their horizontal and vertical components, (3) from the components thus found to determine the resultant force, and (4) then the desired

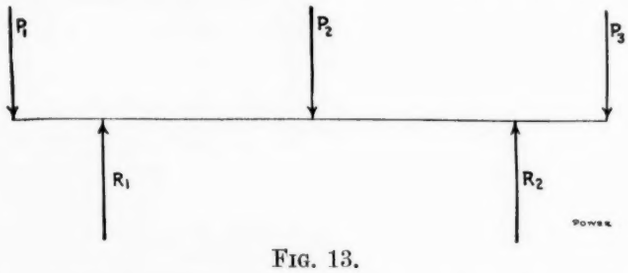


Fig. 13.

force will be a force which is equal and opposite to the above resultant.

To demonstrate this principle take the ordinary type of flywheel governor, as shown in Fig. 14. As the engine speeds up, or slows down, the balls $B$ and $A$ move farther away from, or closer to the spindle $OD$. When the engine is running at a uniform speed the governor balls remain at a fixed distance from the spindle.

Let Fig. 15 represent one of the balls as a free body. The line $OB$ is drawn parallel to the line $OA$ and represents the resistance offered by the arm. The line $OE$ is vertical and proportional to the weight of the ball $A$, and the horizontal line $OF$ indicates the centrifugal force tending to pull the ball $A$ in a straight line. Construct the parallelogram $BOENB$ and draw the diagonal $ON$, which is the resultant of the forces $T$ and $W$. The

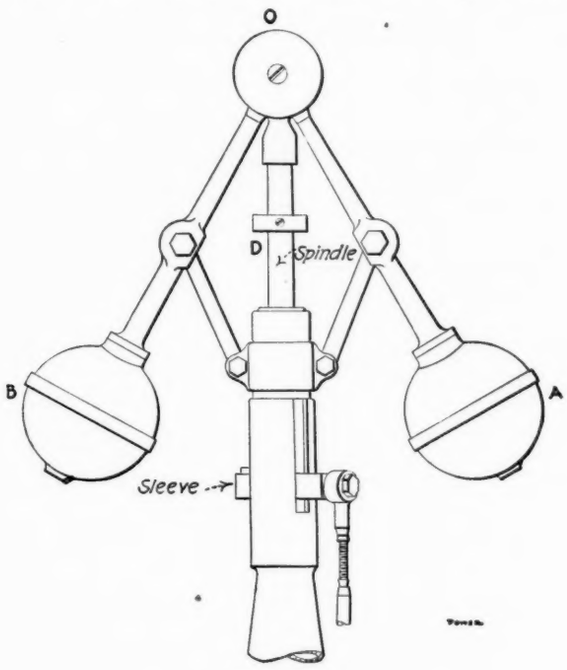


Fig. 14.

centrifugal force exerted by the ball $A$ must then be equal and opposite to the resultant $ON$, and when such a condition holds true all the forces are in balance and will continue to be so until the speed of the engine changes. This will change the value of the centrifugal force $C$ and then the arm $OA$ will take a new position until the forces again come into a state of equilibrium.

### Triangle of Forces

When three forces acting in the same plane keep a body in equilibrium the resultant of any two of the forces must be equal and opposite to the third force. For this to be true the third force must pass through the same point as the other two. *Therefore, when three forces acting in the same plane produce a state of equilibrium, these forces must pass through a common point.*

*Example*—Let Fig. 16 represent a common form of wall crane and assume the load as acting at the point $A$. This load $W$ causes (1) a tension or pull in the tie-rod $AC$ which is counteracted by the rod exerting a corresponding reaction $T$, from $A$ to $C$; and (2) a compression or push in the beam $AB$, which is counteracted by the reaction $P$ of the beam from $B$ to $A$. From the previous discussion it follows that the resistance offered by $BA$ is equal and opposite to the resultant of the tension in the tie-rod $AC$ and the weight $W$.

Let Fig. 17 represent the point $A$ as a free body. The line $OG$ replaces the resistance offered by the beam $BA$, the line $W$ replaces the weight $W$, and the line $ON$ replaces the resistance offered by the rod $AC$. From the point $N$ draw the line $NH$ equal and parallel to the line $W$. Draw $HO$ equal and parallel to $OG$. There is thus formed the triangle $ONHO$ in which it will be noted that the force $T$ is acting from $O$ to $N$, the force $W$ from $N$ to $H$, and the force $P$ from $H$ to $O$. In other words, the three forces acting on the point $O$ have been replaced

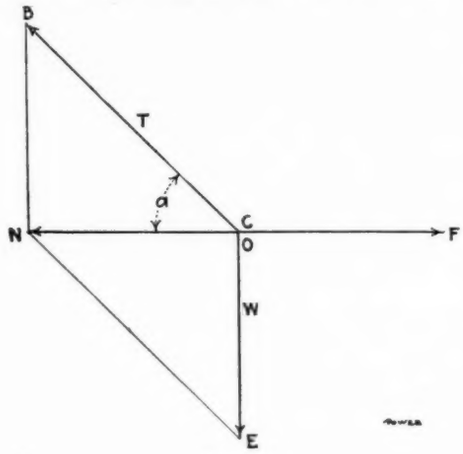


FIG. 15.

by a triangle which is called a *force triangle*. Hence the following rule can be stated:

*When three forces acting at a given point on a body are in equilibrium, these forces can be represented in direction and magnitude by the sides of a triangle taken in order, if the sides of the triangle are parallel to the respective forces. Conversely, if three forces acting on a body can be represented in direction and magnitude by the sides of a triangle taken in order, the forces will be in equilibrium.*

This law is simply another application of the parallelogram of forces. The important part of the law is that

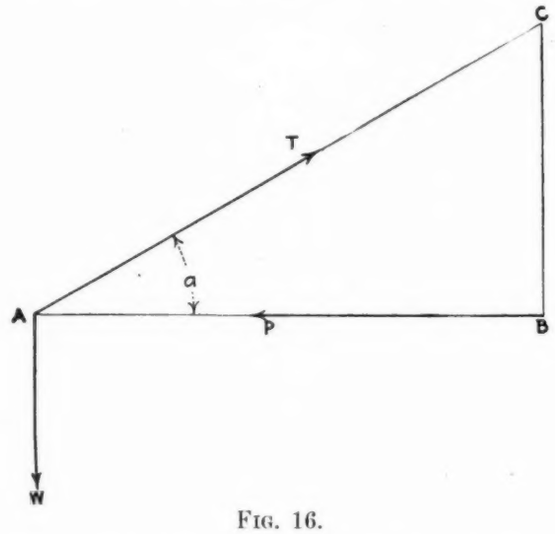


FIG. 16.

the sides must be taken in the same order, or in the same way around. This law does away with the necessity of resolving forces into their horizontal and vertical components. Thus in the triangle $ONHO$ (Fig. 17) the angle $NOH$ must equal the angle $a$ (which is known) and the side $NH$ equal the known weight or load $W$. The hypotenuse $ON$ will then equal the unknown tension $T$ in the tie-rod $AC$ and the base $OH$ will give the compression in the beam $AB$.

*Example*—Suppose the angle $a$ (Fig. 16) is 30 deg. and the load $W = 1000$ lb.; what is the tension $T$ in the rod $AC$, and what is the compression $P$ in the beam $AB$? Use the force triangle of Fig. 17, letting the angle $NOH = 30$ deg. and the line $NH = 1000$ lb.

$$\sin a = \frac{NH}{ON} = \frac{W}{T}$$

therefore,

$$T = \frac{W}{\sin a} = \frac{1000}{0.5} = 2000 \text{ lb.}$$

Also

$$\tan a = \frac{NH}{OH} = \frac{W}{P}$$

therefore,

$$P = \frac{W}{\tan a} = \frac{1000}{0.577} = 1732 \text{ lb.}$$

This problem is comparatively simple because the triangle contains a right angle.

### STUDY QUESTIONS

16. Two forces of 80 and 100 lb. act on a body and make an angle of 60 deg. with each other. Find the direction and magnitude of a third force to produce equilibrium. Assume the force of 100 lb. as horizontal.

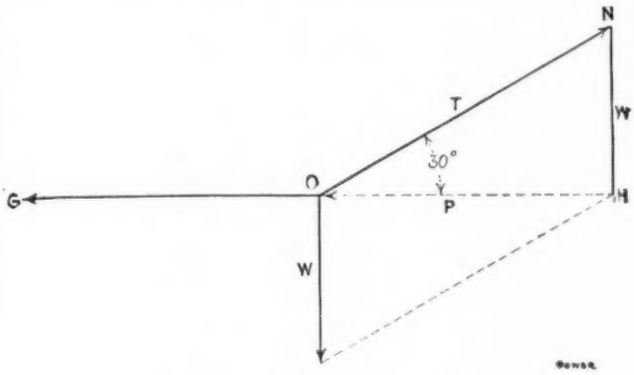


FIG. 17.

17. In Fig. 16 the tension $T$ must not exceed 2000 lb. If the angle $a$ is 35 deg., what is the maximum load that can be suspended from the point $A$?

18. In Fig. 15, if the weight $W = 40$ lb. and the centrifugal force $C = 30$ lb., determine the tension in the arm $OB$.

19. In Fig. 16, let the weight $W$ be suspended at a point midway between the points $A$ and $B$. Will the tension in the tie-rod $AC$ be increased or decreased?

20. Will the pressure at the point $B$ remain horizontal? If not, how could its line of action be determined?

**To Teach Fuel Economy**—To teach employees of the Northern Pacific Ry. system how to use coal economically, and how to avoid creating smoke nuisances, George T. Conley, fuel supervisor of the system, will deliver lectures at the principal stations on the line. Mr. Conley will travel in a special car fitted out to serve as a lecture hall, and it is estimated that he will consume more than a year in completing the course of instruction.

## OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

### The Passing of a Bad Bill

By R. T. STROHM

Last week Josiah Barlow's Bill
Begun to work at Hooker's mill.
For he was such a gol-darned fool
It warn't no use to go to school.
They turned him loose with brush an' broom
To sweep an' dust the engine room.
About the time that he was through,
The guvner belt bust right in two.
Then that ole engine she cut loose
An' ran to beat the very deuce.
The engineer woke up an' swore,
An' then he beat it for the door.
But thinkin' he might save the mill,
He bellered, "Grab her throttle, Bill!"
Now Bill, poor dub, he couldn't see
Just where her throttle ought to be;
But he was willin', young and spry,
An' when the crosshead caught his eye
He braced his laigs an' took a breath
An' gripped it with the grip of death.
It rastled poor Bill to an' fro
Some eighteen thousand times or so.
His laigs went floppin' everywhere,
Now on the floor, now in the air.
It banged his bean down on the floor
Some twenty million times an' more
Before Bill got a little wit
An' thought he'd best let go of it.
But when he let it go at last,
Poor Bill was speeded up so fast
He slithered off acrost the floor
An' then out through the open door.
He took the pasture in a jump
An' sailed right by the village pump.
He bounced along the quiet street,
Now on his head, now on his feet,
An' so on through the big glass plate
Up at the store of Old Man Tate.
He knocked it into smithereens
An' come to rest among some beans
An' prunes an' rice an' other trash
So dry an' hard they couldn't smash.
Bill sot there for a little while
A-smilin' of a thoughtful smile,
An' while he thought he took a prune
An' absent-minded got to chewin.'
Then Old Man Tate he lost his head.
His face went white, his neck got red.
He yelled "Police!" an' Jacob Dunn
Come tearin' up street on the run.
Whenever Jake don't get too full
He is our local constabull.
He sorted Bill out from the beans
An' pulled a pistol from his jeans,
An' told Bill not to stop or talk
But step off at a lively walk.
Bill saw that balkin' was no use
An' marched off to the calaboose.
We thought the Court would make him pay
For bustin' up the store that way;
But sakes alive! Judge Adam Squeers
Gave Bill a term of seven years
For stealin' prunes from Old Tate's shop.
Sez he, "This wave of crime must stop!"
Bill took his sentence ca'm enough
But said he thought it kind of tough
To make him run so far an' fast
To get one measly prune at last.

⁂

"That's our general superintendent—son of the president—he began at the bottom and worked up—started in being an oiler, right after he left college!"

"When was that?"

"Oh, he graduated last June!"—"Puck."

Now, oilers, if your dad's a president, show him the joke—and you'll probably be worked up. If he's not, you'll be worked up, anyhow.

## Buying Coal on Specification

By F. G. LEMKE

In the plant the writer operates coal is purchased on the specification basis. All coal delivered must be of a quality equal or superior to the standard analysis for the various sizes given in Table 1.

TABLE 1. STANDARD ANALYSIS

| Size of Coal | Per Cent. Moisture as Delivered | Per Cent. Ash in Dry Coal | Per Cent. Volatile Combustible Matter in Dry Coal | Per Cent. Volatile Sulphur in Dry Coal | Heat Units per Lb. of Dry Coal |
|---|---|---|---|---|---|
| Egg | 4 | 11 | 8 | 1½ | 13,200 |
| Stove | 4 | 12 | 8 | 1½ | 13,000 |
| Pea | 5 | 17 | 8 | 1½ | 12,300 |
| Buckwheat No. 1 | 6 | 18 | 8 | 1½ | 12,200 |
| Buckwheat No. 2 | 6 | 19 | 8 | 1½ | 12,100 |
| Buckwheat No. 3 | 6 | 19 | 8 | 1½ | 12,000 |

As it is important that the coal used should be as uniform as possible, any variation in size greater than allowed in Table 2 is cause for rejection.

TABLE 2. SPECIFICATIONS ON SIZE

| Size of Coal | 90 Per Cent. Should Pass through Square-Mesh Screen In. | 90 Per Cent. Should Pass over Square-Mesh Screen In. |
|---|---|---|
| Egg | 3 | 2 |
| Stove | 2½ | 1¼ |
| Pea | 1 | ¾ |
| Buckwheat No. 1 | ¾ | ½ |
| Buckwheat No. 2 | ½ | 5/16 |
| Buckwheat No. 3 | 5/16 | 3/16 |

A sample of the delivered coal is taken at the point of weighing; about 200 lb. for a 100-ton delivery. This is reduced by quartering to about 5 lb., which amount is put into moisture-proof receptacles, and taken to a specified laboratory for analysis to determine the percentage of moisture, ash, volatile combustible matter and volatile sulphur. The heat units are determined by means of a bomb calorimeter.

Correction is then made in the gross weight delivered, for any excess per cent. found over that allowed in the standard analysis, at the following rates:

For excess moisture, the gross weight is corrected by an amount directly in proportion to such excess per cent. For instance, an excess of 2 per cent. moisture will reduce the gross weight 2 per cent. and so on.

For excess ash, the gross weight (corrected for moisture) is reduced at the rate of 1 per cent. for each 1 per cent. of ash found in excess of the standard.

For excess volatile combustible matter, the gross weight (corrected for moisture) is reduced at the rate of 2 per cent. for each 1 per cent. of volatile combustible matter found in excess of that allowed.

For excess volatile sulphur, the gross weight (corrected for moisture) is reduced at the rate of 5 per cent. for each 1 per cent. of volatile sulphur exceeding that allowed.

For B.t.u. below that specified the gross weight (corrected for moisture) is reduced at the rate of 1 per cent. for every 100 B.t.u. below the specified amount.

All deductions for ash, volatile combustible matter, volatile sulphur and heat units are then added together and subtracted from the gross weight as corrected for moisture. The balance is the weight paid for. This method has given good results. No check analysis is allowed on moisture, as the first result is final.

⁂

Electrification of the Norwegian government railroads is the subject of a newly submitted report by a special commission. The excessive prices of imported coal (Norway having no coal mines) led to the investigation of the feasibility of using "white coal," and the electrification of seven trunk lines at a cost of $9,000,000 is recommended.

# Causes and Prevention of Boiler Corrosion

By Francis H. Davies

*SYNOPSIS—Internal and external corrosion, pitting, the forming of acids, electrolytic action and the use of zinc plates to retard its effect.*

Under ordinary conditions of working the principal cause of steam-boiler deterioration is corrosion. Wasting may be said to commence immediately after the rolling of the plates, and through its entire life a boiler is continuously subjected to an insidious process of decay which is often difficult to locate and to prevent. Broadly speaking, there are three main forces which contribute to the gradual destruction of a boiler. The chief are chemical and electrical action, but mechanical movement or strain is also largely responsible. The effect of these actions is apparent both internally and externally, the former being more dangerous and complicated than the latter as the destructive forces at work are more numerous. External corrosion usually becomes evident before much harm is done, and almost without exception the cause is oxidization or rusting brought about by various means. Moisture is, of course, the root of this trouble, and its presence may be due either to exposure to the atmosphere, the careless use of water around the boilers, leaky seams and rivets or the absorption of water by the brickwork.

Of the careless use of water around the boilers the best example lies in the practice of quenching ashes when the fires are cleaned. A result is the formation of sulphuric acid which rapidly corrodes any metal it may come in contact with. Should it collect on the plates in its earlier forms of $SO_2$ or $SO_3$ it is harmless, but any small leaks which may occur at seams or rivet heads will add to the trouble at once by providing the necessary moisture. Such small leakages are generally ignored as they do not in themselves constitute a serious source of weakness and are often difficult to calk, but if left unattended it will only be a question of time for the combined eroding and corroding actions to produce a more serious state of affairs. It must be borne in mind that rusting or oxidation is greatly facilitated by heat and also by the presence of carbon in the form of coal dust. Add to these moisture to an appreciable degree and the result is the formation of ferrous carbonate on the plate, which in turn is oxidized and changed into ferric oxide. Carbonic acid is liberated during these chemical reactions and in conjunction with oxygen from the air assists in decay of the metal.

In Lancashire boilers, external corrosion is most marked in the flues and close to the brickwork. The latter is capable of retaining a great store of moisture, and hence the well known and dangerous result of corrosion at the seatings. Should the boiler be situated on damp ground it is essential that it should be provided with a good concrete foundation as this is the only means of keeping out moisture which rises from the ground. So far as the brickwork is concerned, the best plan is to place sheets of iron between it and the boiler, in which case the sheets alone will be attacked. Owing to the destructive action of lime when wet, clay mortar only should be used in close proximity to the plates. Flue corrosion arises from the fact that the gases are rich in the products of sulphur and carbon, which in the presence of moisture form a powerful corrosive agent.

So far only chemical action has been considered, but it is also necessary to take into account the equally destructive electrical action which is the natural sequence of the chemical effects. Iron oxide is electro-negative to iron, and the two in conjunction with even the smallest amount of moisture form an active electric cell which rapidly eats away the metal. This is particularly the case in flues where the electrolyte formed by the combination of flue gases and moisture is, electrically speaking, more highly exciting than moisture alone. The same effect is noticeable in iron coal bunkers, where the contact of wet coal with the plates sets up electrical action and eats away the latter, but perhaps the best example of electrolytic corrosion is provided by brass or gunmetal fittings, such as water and pressure gages, check valves, etc. The unequal expansion of the two metals gives rise to leakage, and this provides the remaining essential for the formation of an electric cell. In such cases corrosion is often rapid and subsequent trouble will be avoided if such fittings are from the first thoroughly looked after.

Internal corrosion presents a more difficult problem than the foregoing, as the number of destructive forces to take into account is greater. Grooving is well known to be a serious disease, which, arising in the first place from faulty construction and too rigid staying, is greatly aggravated by corrosion. There is a considerable difference in the temperature of the top and the bottom of a furnace tube, which consequently tends to arch. This should be and generally is provided for, but if expansion is too greatly restricted by staying, the plates of the furnace tube are subjected to severe stress, and, unless very ductile, the continued repetition results in cracks which usually occur at the furnace end. The fresh metal thus exposed is immediately attacked by any acids which may be present in the water and the original crack is in course of time developed into a groove. This serious defect cannot be remedied without somewhat drastic alterations in the construction of the boiler, but further weakening may be prevented by judicious reinforcing of the plate.

The familiar phenomenon of pitting may arise from several causes, both chemical and electrical. During the process of rolling the plates small pieces of carbon and slag are sometimes forced into the metal, and when these come under the influence of the water in the boiler, electrolytic action is at once set up and the metal in close proximity to the fragment of scale is eaten away. There are, however, more common causes than this, and perhaps the most prevalent arises from oil in the feed water. An animal or vegetable oil decomposes into various acids when subjected to heat, and these naturally attack the plates, particularly in positions where the emulsified oil has settled upon them. There is no excuse for the employment of such oils in engine cylinders as the harm

they effect is well known, but the fact remains that through a mistaken idea of economy they are still often employed knowingly and perhaps more often unwittingly as adulterants in mineral oils. Cheap oil in a condensing plant is always a mistake, as boiler corrosion is an inevitable sequel. Pitting is often found internally opposite the lines of seating, and in this case it arises from the comparative coolness of these portions and the presence for a longer time of the occluded gases in the water. Also, there is little doubt that it is accentuated by electrolytic action arising from the difference in temperature of the two parts of the plates. Such temperature difference acts upon the molecular structure of the metal in such a way that the part of the plate at the higher temperature becomes electro-positive to the cooler part, and the former is consequently corroded. The same effect is found in furnace tubes at the sides, and generally. cases of pitting which seem inexplicable may often be traced to this cause.

General wasting and pitting arise from the presence of air or oxygen in the water, the plates being attacked and an oxide or scale formed. Iron does not rust in pure and dry air or oxygen, neither does it corrode in pure distilled water entirely free from oxygen, but if both are present as must necessarily be the case in ordinary practice, the result is that natural wasting which terminates the life of a boiler by simple old age.

For the purpose of retarding electrolytic action, it is customary to place in the boiler zinc plates connected electrically to the shell. The principle is to deliberately set up electrolytic action between the two, but the zinc suffers, being electro-positive to iron or steel, and the boiler shell is protected from the electrically exciting action of any acids that may be present in the water. There is no question that this is an effective way of mitigating corrosion, but everything will depend upon the manner in which the arrangement is installed. It is quite useless to place a zinc slab in a boiler without any electrical connection, although this is frequently done; neither will it be effective to suspend the slab from some convenient stay by a loose piece of wire. A sound and substantial electrical connection with the shell must be made, and the best arrangement is to nut down several zinc slabs to studs screwed into the sides of the furnaces or combustion chambers. The slabs should be about 1 in. thick and should each have an area of, say, 60 sq.in. The contact surfaces should be thoroughly clean and bright, and the nut screwed up hard enough to keep moisture from finding its way between them. This is a much more satisfactory arrangement than that of attachment by wires, soldered or otherwise, since such connections are in the way during cleaning and seldom have sufficiently ample contact surface.

For a new boiler satisfactory and effective protection will be obtained by using the proportion of 1 sq.ft. of zinc to every 50 sq.ft. of heating surface, but as the boiler ages this proportion may safely be reduced to 1 to 75 or 1 to 100.

# Alignment and Care of Turbo-Generators

By H. M. McLellan

A perfect alignment must be secured and maintained between the rotating parts of the turbo-generator set. Any out-of-alignment causes wear on the coupling faces and tends to create vibration. Special care must be taken that plenty of oil is conveyed to the coupling faces through the oil holes provided for that purpose. Lack of sufficient lubrication at this point will cause excessive wear in the coupling, with consequent vibration. Ordinarily, the clearance between the two halves of the coupling should not be less than $\frac{3}{32}$ in. with the halves as close together as the bearings will allow, when cold.

Bearings must always be adjustable so as to secure the best possible alignment. The working clearance in the bearings should be as small as possible, and should not exceed 0.01 in. The end clearance must also be small, not exceeding $\frac{1}{32}$ in. on each bearing for the exciters, and from $^3/_{64}$ to $^5/_{64}$ in. on each bearing for the generators. The end clearances may, of course, be increased where end motion is prevented by the coupling. Also the thrust shoulders on the shaft should be generously proportioned.

Care must be taken that the oil is retained in the bearings, and does not escape or creep along the shaft and get into the generator windings as it will eventually destroy the insulation.

The stator must be set magnetically central with the rotor, both longitudinally and radially. The longitudinal position can best be determined by running the set excited and adjusting the position of the stator until all end thrust is eliminated. When this position is obtained, the stator should be securely doweled to its base. When erecting on its site, it will generally be sufficient to divide the clearance between the rotor and the end covers equally at each end, as these clearances are usually adjusted to suit the magnetic center when on the testing floor of the manufacturer. In no case should these clearances be materially altered without first referring the matter to the makers.

A perfect balance in the rotating parts must be obtained. In many cases where there is difficulty, the trouble is not due so much to lack of balance as to a lack of proper alignment, imperfect fitting of coupling, or excessive clearance in the bearings; hence the necessity for eliminating all chance of trouble by proper attention to these points when erecting. If it is suspected that the trouble is due to the rotor being out of magnetic balance, this can be determined by running the machine unexcited, and comparing with the balance when excited.

Of course, the brushes must be properly bedded, and have the faces clean and smooth, and kept from chattering. If sparking takes place, the cause should be ascertained and removed, as a continuance of this trouble will rapidly destroy the brushes and also the surface of the slip rings or commutator. The mica between the bars on the exciter commutator should be filed down, and

copper picking by the brushes should be stopped by using paraffin on the commutator, running without load until it has taken a polish. Trouble which cannot immediately be remedied on the brush gear should be reported to the maker, as it is cumulative in its effect and rapidly destroys the brushes and collecting gear.

Sparking at the brushes may be due to any of the following:

(1) Brushes may be jammed in holders.

(2) Brushes may require facing up.

(3) Brushes may be pressing too tightly on the slip rings.

(4) The rings may be rough. If so, they should be smoothed off. The rings should run smoothly and true with a dark, glossy surface.

(5) The machine may vibrate excessively, due to poor foundations, or to the revolving field being out of balance.

(6) The rings may be dirty or oily.

When brushes used with radial-type slip rings are made to lie at an angle other than 90 deg., the direction of rotation should be against the angle.

The machine should be kept clean and free from oil and moisture. Compressed air may be used for blowing out dust or dirt, at a pressure usually not exceeding 40 lb., and care should be taken that the air contains no moisture.

All insulation washers or collars, or surface insulation, should be given special attention and be wiped clean whenever necessary. All screws, connections and terminals on the machine must be kept tight. If any connections or terminals show signs of becoming dirty or corroded, their ends as well as the contact parts must be thoroughly cleaned.

## Engineers' Improved Slide Rule

By D. E. Foster*

The customary way of obtaining the circumference of a circle on the ordinary slide rule is to place the figure 3.1416 of the $C$ scale opposite the figure 1 or 10 on the $D$ scale. This process may be simplified by the addition of a second $D$ scale placed on the edge of the rule beneath the regular $D$ scale, with the figure 3.1416 of the new scale in line with the figure 1 above it on the regular $D$ scale. By setting the cross-hair over the given diameter on the regular $D$ scale, the operator can find the circumference at once on the scale below.

One of the usual ways of obtaining the area of a circle on the rule is to set the figure 1 or 10 on the $C$ scale opposite the given diameter on the $D$ scale. The result is then found on the $A$ scale opposite the figure 0.7854 on the $B$ scale.

Another method is to place the figure 0.7854 on the $B$ scale under the figure 1 on the $A$ scale. The area is then found on the $B$ scale after the cross-hair has been placed over the given diameter on the $D$ scale.

These processes may be simplified in a manner similar to the one described above by the addition of a second $A$ scale located on the upper edge of the rule above the regular $A$ scale, and set to the right a distance sufficient to make the figure 0.7854 of the new scale lie directly over the figure 1 of the regular $A$ scale. By setting the cross-hair over the diameter on the $D$ scale, the result may be found on the new $A$ scale.

A glance at the illustration will suffice to show how these results may be accomplished. The cross-hair indicator is not shown in the figure, as it was removed to facilitate the photographic work necessary to build up the illustration.

The advantage of being able to obtain the circumference and the area of a circle at a single setting of the cross-hair without moving the slider is evident. There is another advantage, however. Suppose one wishes to know the area of a circle when he has the circumference. He sets the cross-hair on the figure representing the circumference on the new circumference scale and reads the area of the circle on the new area scale. At the same time he may read the diameter on the $D$ scale and the area of a circumscribing square on the $B$ scale. Hence it is evident that if one of these four functions is known, the other three may be determined by one setting of the cross-hair. There are a number of other common problems that will be considerably shortened by the use of these two new scales.

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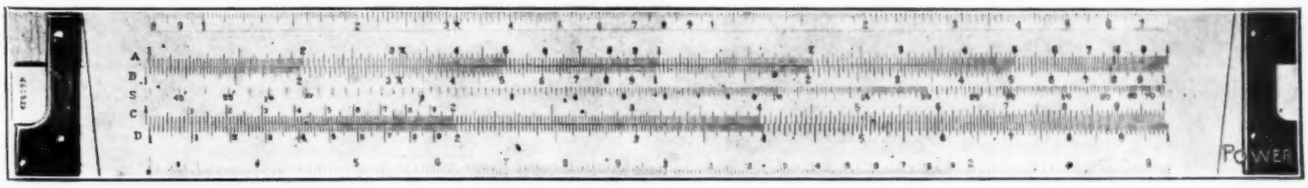
## Auld's Safety Valve

A design of safety valve, the invention of David Auld & Sons, Ltd., Glasgow, is illustrated herewith. It is of the class adapted to allow overpressure steam to escape from the full area of the main valve or nearly so, the main valves being opened by the steam pressure acting on one side of a piston secured to the main valve when the pressure on the other side of the piston, which maintains the valve in the closed position, is relieved by auxiliary-valve opening by the action of the overpressure on a piston secured to the auxiliary valve. In this design only one cylinder is employed for the two pistons, which are connected to the main valves, and fitted to move simultaneously in opposite directions, while a cage arrangement is adapted to hold the moving parts in position while permitting them to be easily withdrawn for inspection or repair.




Improved Slide Rule with Extra Scale Top and Bottom

Fig. 1 is a front elevation of a double safety valve, Fig. 2 is a corresponding side elevation partly in section, and Fig. 3 is a front sectional elevation. The inlet $A$ and the outlet $B$ are formed by the casing of the valve, and are separated by that portion forming the cylinder $C$.

Within this cylinder are fitted the pistons *D* and *E*, which are formed in one with the two main valves *F* and *G*. A guide pin is screwed into the piston *D*, and enters an eye in the piston *E* to act as a guide and steady the motion of the pistons. The seat for the valve *F* is formed on the casing and the seat for the valve *G* on the cage device *H*. Regulating springs are fitted around the spindles of the main valves. The auxiliary or regulating valve consists of a valve *J* connected by a spindle to a piston *K* below which is always open to the steam pressure through the duct *L* leading from the boiler to the chamber *M*. The valve spindle is hollow above the valve and is formed with a piston *N* to balance the valve *J*. A spring is provided for controlling the action of the valve *J*. The steam is led from the space between the pistons *D* and *E* by the port *O* and duct *P* to a chamber *Q* below the regulating valve *J*.

The action of the valves is as follows: Fluid pressure enters the main-valve casing by the inlet branch *A* and flows along the ports or ducts *R* into the space between the main valves *F* and *G* and main pistons *D* and *E*. The

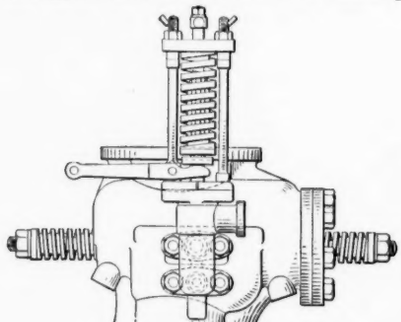


FIG. 1

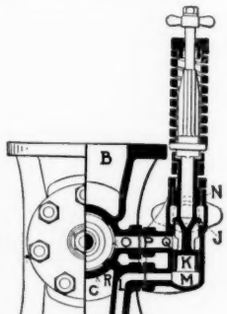



FIG. 2

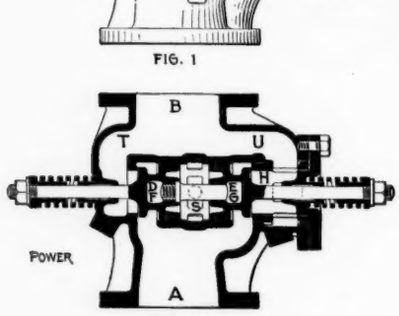



FIG. 3

DETAILS OF AULD'S SAFETY VALVE

fluid pressure also leaks past the main pistons into the space *S* in the main cylinder *C*, thereby acting on the opposite sides of the main pistons and holding the main valves tightly to their seats. The fluid pressure in the space *S* between the main pistons passes through the port *O* and duct *P* to the chamber *Q* under the regulating valve *J*. The inlet pressure also passes by the port or duct *L* to the chamber *M* and acts on the underside of the piston *K* connected to the regulating valve *J*. This regulating valve is loaded to a predetermined pressure by means of the spring shown, and immediately the inlet pressure tends to exceed this amount the regulating valve *J* is forced off its seat by the pressure on the piston *K* and under the valve overcoming the force exerted by the spring. On the regulating valve *J* opening the pressure contained in the space *S* between the main pistons is exhausted through *O* and *P* reducing the pressure.

Although the pressure under the regulating valve *J* is altered by this action the adjustment of the regulating valve is kept constant by the inlet pressure constantly acting under the piston *K*. The pressure contained in the space *S* between the main pistons being considerably reduced, the initial pressure acting on the annular part around the outside of the main pistons overcomes the pressure holding the main valves on their seats, thereby opening the main valves. Fluid pressure now flows through the valve seats into the outlet branch *B* from the valve *F* by the duct *T*, and from the valve *G* through openings in the cage device *H* and duct *U*. When all the surplus pressure has been discharged the spring closes the regulating valve *J*, shutting off the escape of pressure from the space *S* between the main pistons, wherein the initial pressure then accumulates and closes the main valves by acting on the main pistons. The same cycle of operations is repeated so long as the inlet pressure tends to rise above that to which the regulating valve is set. When the regulating valve *J* is opened by means of the hand easing gear provided, the main valves will be opened in the same manner as when the regulating valve *J* automatically opens, due to overpressure.—*The Mechanical Engineer.*

## Three-Wire Generator with Revolving Compensator

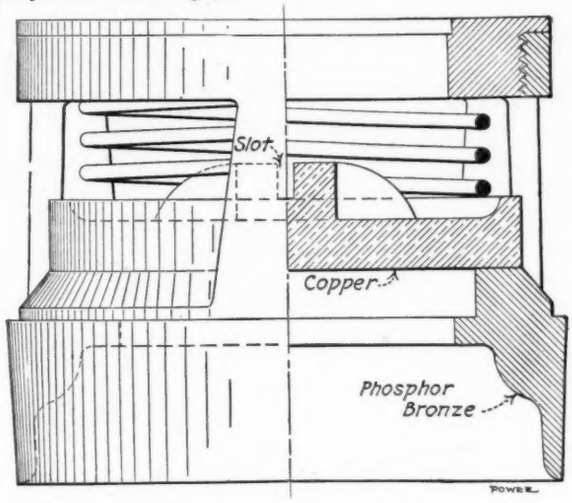
The adoption of a revolving compensator with one collector ring for obtaining the neutral connection with three-wire operation is embodied in a design recently brought out by the General Electric Co., superseding the familiar separate stationary compensator and two collector-ring arrangement. The revolving compensator consists of a circular magnetic core upon which are mounted suitable exciting coils, the core with its coils being assembled on a cast bracket bolted directly to the back end of the armature spider, as shown in Fig. 1. The compensator fits under the overhanging end windings of the armature, projecting only a short distance beyond the main winding.

The compensator windings are connected to the main armature winding at proper points, and the neutral connection is taken through the armature spider to a single collector ring mounted on the outer end of the commutator shell. This ring may be seen in Fig. 2. The neutral brushes bearing on this ring are supported by and insulated from the main brush-holder studs. The simplicity of this design, self-contained with the armature, eliminates floor space taken by the stationary compensator, requires fewer collector rings and brushes and reduces the number of cable leads to the switchboard. These generators are of the commutating-pole type.

**The Construction of Large Brick Chimneys** is a job for skilled workmen. The taper, which sometimes changes several times in the height of the stack, is determined by a templet of triangular form, having a plumb line and bob on the vertical side and a spirit level on the horizontal (top) side, the third side being cut to the proper angle. The work is checked frequently by the inspector, who makes measurements of the interior diameter. The bricklayers work on a platform supported by two or four cross timbers. An upright post fastened to the inside of the stack projects above the platform and carries a horizontal timber (with inclined braces), having a pulley at each end. The hoisting line from an engine on the ground passes over these pulleys and down inside the stack, the material being hoisted generally on the inside. If it is to be hoisted on the outside the cross timber is made long enough to carry the pulley clear of the base of the stack. (From a paper by E. E. T. Tratman, read before the National Brick Manufacturers Association.)

## T and R Pump Valves

A new design of pump valve and valve seat has recently been placed on the market by Tryon & Reid, 67 Montgomery St., Newburgh, N. Y.




VALVE AND SEAT CASING

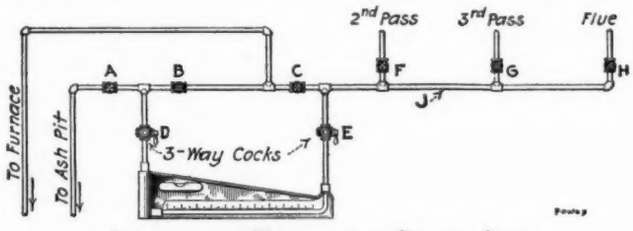
The seat and bushing, which is fitted to the valve deck of the pump, has its inside thread at the top in which a cap is screwed to keep the valve spring in place.

The copper or brass valve disk has a flat seating surface. The three brackets between the base of the bushing and the top of the cage keep the valve in place, which insures proper seating, and its saucer-shape top prevents the bottom of the spring from working out of place. This design allows the valve disk to raise to a sufficient height to discharge freely. The stem is eliminated and there can be no wear at the center of the disk.

## Draft-Gage Piping

BY D. MCGREGOR

The accompanying sketch shows how a boiler may be piped to a differential-draft gage to obtain the various readings and be adaptable either to forced- or natural-draft conditions. The arrangement requires ¼-in. pipe fittings, six straightway and two three-way cocks; the latter can be made out of regular cocks by drilling a




PIPING AND VALVES FOR DRAFT GAGE

small hole through the side of the body and half-way through the plug when set open.

Following is a list of readings and how they are taken; all cocks are to be closed except those mentioned.

For the ashpit pressure, open the valves *A* and *BD*, straightway, and the three-way cock *E* to the atmosphere.

For the furnace pressure, open the *BD* valves, straightway, and the valve *E* to the atmosphere.

For furnace suction, open valves *CE*, straightway, and valve *D* to the atmosphere.

If it is desired to determine the drop in draft through the fuel bed, open *AC* and *DE*, straightway.

For the drop in pressure from the ashpit to the second pass, open the valves *AF* and *DE*, straightway.

For the drop from the ashpit to the third pass, open the valves *AG* and *DE*, straightway.

For the total available draft from the ashpit to the flue, open the valves *AH* and *DE*, straightway.

For the drop through the boiler from the furnace to the second pass, open the valves *BF* and *DE*, straightway.

For the drop through the boiler from the furnace to the third pass, open the valves *BG* and *DE*, straightway.

For the drop from the furnace to the flue, open the valves *BH* and *DE*, straightway.

For the draft at the second pass, open the valve *D* to the atmosphere and *E* and *F*, straightway.

For the draft at the third pass, open the valve *D* to the atmosphere, and *E* and *G*, straightway.

For the draft in the flue, open the valve *D*, to the atmosphere, and *E* and *H* straightway.

Unless otherwise stated, the valves *D* and *E* are opened straightway from the draft gage.

## Newark N. A. S. E. Holds Big Meeting

On Monday evening, Apr. 6, Newark No. 3 Association, of the National Association of Stationary Engineers, held a banner educational meeting. When about 200 members and visitors attended an illustrated lecture on "Modern Boiler Room Practice," by Charles H. Bromley, associate editor of "Power."

The presence at the meeting of Harry C. Cosins, first National President, one of the founder of the N. A. S. E. and the present national president, James R. Coe, gave added interest to the occasion.

Although the lecture was not to begin until 8:30, the hall was overcrowded long before this. It was necessary to remove a portable partion betwen the main and rear halls to accommodate those present. The associations of New Jersey showed their interest in the occasion by being represented by several members each, many men coming from as far south as Perth Amboy. Several engineers from New York and Brooklyn were also present.

Number three association has entered this lecture for the prize offered by the National officers.

## Recent Court Decisions

Digested by A. L. H. STREET

**Validity of Contract for Joint Use of Poles**—A telephone company, having encountered difficulty in securing authority from a city to erect poles and wires along a street, agreed orally with an electric company, which had existing poles, that if the electric company would permit it to erect poles for the use of its wires in place of the electric company's poles, it would permit the electric company to put up and keep its wires, etc., on these poles and on any other poles owned by the telephone company on other streets. Dispute having arisen between the companies, the telephone company sued to compel the electric company to remove its wires from the former's poles. In affirming a decree which dismissed the suit, the Kentucky Court of Appeals recently held in this case (East Tennessee Telephone Co. vs. Paris Electric Co., 162 "Southwestern Reporter" 530) that although the contract was originally invalid under the Kentucky statute which requires agreements not to be performed within one year from their making to be reduced to writing, this invalidity was cured by part performance of the agreement, the telephone company having erected the poles and the electric company having installed its wires thereon. But the court decided that the electric company did not acquire a perpetual right to use the other company's poles, and that the telephone com-

pany might bring a new suit to terminate the contract upon terms equitable to the electric company, if it can show that the public will be better served by an abrogation of the agreement. Touching the right of the electric company to grant the right to the telephone company to occupy the street, the court said: "The privilege of using the streets of a city cannot be granted by one public service corporation to another public service corporation. It can only be acquired in the manner pointed out in section 164 of the Constitution. So that, unless the telephone company had acquired from the city the right to occupy Main Street, it did not secure by its contract with the light company anything of value, because the light company had nothing to give it."

**Nature of Government Water Power Privileges**—The legal status of a contract by a water power company to construct a lock and dam for the Federal Government in a stream, in consideration of the privilege of using the water power produced by the dam in generating electric power, was involved in the recent case of the United States vs. the Chattanooga & Tennessee River Power Co., 209 "Federal Reporter" 28. In deciding that such an improvement constitutes "a public work of the United States," within the meaning of a federal statute which prohibits a contractor for such work from requiring or permitting any laborer or mechanic employed thereon to work more than eight hours in any calendar day, except in case of extraordinary emergency, the United States Circuit Court of Appeals said:

"The acts authorizing the contract, and the contract itself, provide for the construction of an efficient lock and dam in the Tennessee River; and the power company is required to and does undertake at its expense to furnish everything (save only the plans and certain specified materials which the Government is to furnish), and to do all that is necessary to accomplish this result, and to vest title to the whole in the United States; and the power company does this in consideration of receiving from the United States a grant of 'such rights as it possesses to use the water power produced by said dam, and to convert the same into electric power or otherwise utilize it,' for a specified time, subject, however, to the condition that 'nothing shall be done in the use of the water' from the dam to interfere with navigation or with the Government's use and control of the water for that purpose. This clearly limits the grant to the use only of surplus water. If, instead of this, a money consideration had been agreed upon, there could be no question touching the character or ownership of the work; indisputably it would have been one of the public works of the United States. Can it be that the medium of payment can operate to change this result? It is true that this surplus-water privilege is in terms to continue for 99 years; but this is subject to the right of revocation upon payment of the reasonable value of such necessary property as the company may acquire for the enjoyment of the privilege, the value of the 'franchise hereby conferred' being expressly excluded. Thus the surplus-water privilege is at most a determinable franchise; and this is further burdened with an obligation of the power company to 'furnish the necessary electric current while its * * * power plant is in operation to move the gates and operate the locks and to light the United States buildings and grounds, free of cost to the United States.' Now it is not the purpose to minimize the practical value of this privilege while it lasts. The attempt is simply to ascertain and define the nature of the privilege. For it is urged that the main object alike of the enactments and the contract was to produce this surplus-water power privilege and acquire part of the benefits of it, and that the lock and dam were a mere incident. It would be anomalous if the government were to regard its powers concerning navigable waters as entitling it to build locks and dams in navigable streams for the sole purpose of producing water power for the benefit of private persons; and yet this is the logic of counsel's insistence."

## Committee on Electrolysis

A joint National Committee on Electrolysis has been organized with Bion J. Arnold, of Chicago, as chairman and the membership made up of representatives of the various industries concerned. The object and scope of the committee's work is best explained as set forth in the address of Calvert Townley at the New York meeting in February. Mr. Townley said in part:

Electrolytic controversies have in the past given rise to unnecessary and acrimonious disputes, and not infrequently have resulted in litigation between the corporations concerned. The usual procedure in disputes of this kind has been for each side to employ one or more electrical experts who generally disagree as to the cause of the trouble and the remedies therefor. The dispute sometimes gets into the newspapers, occasioning unpleasant notoriety, and resulting in more or less drastic municipal action by the city government concerned. Much of this could be avoided if a body such as this committee could be created which would consider broadly the questions covered by the controversy, without attempting to pass upon the questions at issue, but to report back to their respective organizations so that in time the committee would come to be recognized as a neutral body whose decisions would be authoritative, the same as the Standards Committee of the American Institute of Electrical Engineers in connection with matters of definition and standardization.

Mr. Townley stated that in correspondence he had had with different people, the purpose of the committee was frequently misunderstood; that the impression prevailed in some cases that the committee was going to act as an arbitration board on controversies, and would tell what ought to be done, thereby taking the place of executives or the courts.

## Lecture for Eccentric Firemen on Boiler-Room Methods

On Tuesday evening, Mar. 31, about 400 engineers and firemen of the Eccentric Firemen's Association, attended an illustrated lecture on "Boiler Room Methods," by Charles H. Bromley, associate editor of "Power" at the headquarters in East Forty-fifth St., New York City. Mr. Bromley dealt entirely with the practical side of combustion, the troubles met and their remedies.

After the lecture, Marcus M. Marks, president of the Borough of Manhattan, told of the important work now under way in the various city departments. Timothy J. Healy, president of the firemen's association, presided at the meeting.

**A Manual of Electrical Testing** is the subject of a new 48-page bulletin, issued by the Wagner Electric Mfg. Co., of St. Louis. Besides describing the line of portable instruments manufactured by that company, the publication describes various types of electrical instrument movements, the errors to which they are subject and gives suggestions for their handling and care. The methods of making electrical tests on alternating- and direct-current motors and generators and on transformers are described at length and illustrated.

The bulletin may be had upon application to the Wagner Co.

The 1913 "Proceedings" of the American Water-Works Association have just been issued in a cloth-bound volume of 750 pages, which is obtainable from the secretary, John M. Diven, Troy, N. Y. It contains a complete report of the papers and discussions delivered at last summer's convention in Minneapolis, including, among other subjects: "Rates and Rate Making," "Hydraulic Engineering Education," "Fire Protection Service," Turbine Pumps," "Prevention of Water Waste," "Modern Filter Practice," "Methods of Cleaning Reservoirs," "Mechanical Cleaning of Mains," "The Minneapolis Filter Plant," "Mobile Water Supply," "Memphis Water Supply," "Reservoir Design and Testing Mains."

## ENGINEERING AFFAIRS

Jersey City and Newark N. A. S. E. associations had interesting lectures recently on "Power Costs in Central Stations and Isolated Plants," by H. H. Edgerton, who will be remembered as the expert statistician engaged by Governor Hughes to obtain 80-cent gas for New York City.

## PERSONALS

John Huyette, resident inspector at the Brooks Works of the American Locomotive Co., has ben transferred to the Richmond, Va., plant in the same capacity, and John Gill, special boiler inspector at the Brooks plant, has been promoted to fill the vacancy left by Mr. Huyette.

Elliott H. Whitlock, with 18 years' experience in the carbon industry and the management of plants in other lines, together with a broad practical knowledge of engineering, has opened an office at 1506 West 112th St., Cleveland, Ohio. Mr. Whitlock is a member of the American Society of Mechanical Engineers, the American Electrochemical Society, the Cleveland Engineering Society and the Verein Deutscher Ingenieure.